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PROCEEDINGS

OF

THE ENGINEERS' CLUB

OF PHILADELPHIA

VOLUME XXXI

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PAPER NO. 1132

THE LIMITATIONS OF MATHEMATICAL THEORY APPLIED TO ENGINEERING

By W. G. BUTTON

Read October 4, 1913

Oliver Wendell Holmes, in his "Poet at the Breakfast Table," introduces two characters in strong contrast: the "Master of Arts," who finds the order of things rather narrow, and the "Scarabee," who is appalled by entomology as a whole and confines his investigation to the Coleoptera.

These characters are very suggestive to the civil engineer, who should combine a broad general knowledge of the order of things, with intensive specialization in some particular branch of his chosen profession.

This paper is not intended to decry mathematics, the fundamental basis of engineering, but merely to point out some of the necessary limitations of mathematics as applied to engineering construction.

The branch of pure mathematics most objected to by the practical engineer is the infinitesimal calculus, and some really great engineers have never been able to thoroughly master this subtle instrument of investigation.

It has been said that mathematicians are born and not made.

Probably this is true of such masters as Newton, Descartes and Leibnitz; but it should not deter any engineer from seeking such a knowledge of applied mathematics as will be useful to him in his work.

The late Lord Kelvin, better known as Sir William Thompson, could write down at once the result of many mental transformations in a way that was quite discouraging to his students at Glasgow. The story is told of him that when absent in London, being knighted by the Queen, a member of his class, then enjoying a respite from his short-cut methods, and having the advantage of the more detailed explanations of the assistant professor, Mr. Day, wrote upon the board, "Work while the day lasteth for soon the Knight cometh when no man can work."

Much of the difficulty encountered by the engineer in the use of the higher mathematics is due to insufficient drill in the philosophical basis of the subject. It is especially necessary to get a clear conception of the nature of flowing quantities and their conventional symbolic representation. A thorough knowledge of algebra is also required.

Arithmetic deals with numbers and numbers are discrete quantities, or may be represented as points upon a line.

Now in dealing with certain concepts, such as space, time, and theoretical curves, we are dealing with continuities, which cannot be represented by concrete or discrete numbers. There are no finite steps.

The necessity of some method of representing flowing or continuous quantities so that they could be subjected to analysis, led to the almost simultaneous development of the calculus by Newton and Leibnitz. Newton very appropriately naming his method "fluxions"—Leibnitz's method having a more convenient symbolism was the system generally adopted, and now known as the infinitesimal calculus.

At the first glance the methods of the calculus seem lacking in accuracy because of the throwing away of secondary differentials, but when the nature of "limits" is fully understood it is recognized that the method is essentially accurate.

Some day we shall have the cinematograph film used for mathematical instruction displaying to the student the gradual approximation of the differentials to the perfect curve.

One great difficulty is that of accurate definition unavoidable

in all exact analysis. The idea must be grasped that the zero of the calculus is usually not absolute zero, but only less than any assignable quantity.

A large part of the work of the calculus consists in the summation of an infinite series within certain arbitrary finite limits. If this was its only application, engineers, afteı their student days, might well accept the results obtained by mathematical specialists, as we all do in fact for most of the formulas in use.

But in the design of arches by the elastic theory, in double systems, deflections, the calculus becomes necessary.

Our conceptions of time and space are all based upon a division of these continuous quantities into arbitrary finite steps, varying from the recurrence of cotton planting times, and waxing and waning moons, to the seconds of an astronomical clock.

The calculus has enabled us by the idea of an infinite number of infinitely small steps to write the equation of these continuous quantities. It is conceded that there is great difficulty in getting a thorough comprehension of this idea; but on the other hand we can get ourselves into quite a metaphysical maze if we attempt a philosophical explanation of discrete numbers of integers.

Modern mathematicians are endeavoring to upset our fundamental notions of space with their new geometries.

While the infinitesimal calculus is a wonderful instrument of research in the hands of the skilled mathematician, it is not such a magical solvent of all difficulties as is sometimes assumed. You must be able to write your equation. Irregular curves have to be solved empirically or by the use of mechanical integrars, or methods of integration, such as the well-known planimeter. The writer found ordinary squared paper very useful in integrating time speed curves for rapid transit work, by the simple device of counting the squares.

Another important idea to grasp is that you can get from your mathematical mill only the product of the material that you feed into the hopper.

Mathematics transform, but create nothing.

To solve mechanical questions mathematically, we must abstract certain qualities, and follow determinate lines.

The older books in statics used to show a diagram in which two arrow-pointed lines projected from the ends of a third line at right angles and upon opposite sides. This was supposed to represent

a couple. No explanation was given as to what prevented the whole system straightening out into a right line; the necessary shear resistance not being mentioned.

As a matter of fact, all of the various resisting forces within a body must act together. Tension, compression and shear resistance are all the result of the combined molecular resistance to deformation.

Then we have the expression statics of rigid bodies, rigidity being a relative property of matter progressing through the successive stages of a limpid liquid, a viscid liquid and a plastic solid to a relatively rigid solid such as steel. Steel itself being sufficiently plastic to be drawn into wire, rolled into sheets and pressed cold into many shapes.

All metals can be made to flow under sufficient pressure properly applied. Into this process known as the flow of metals, time enters as an important element. The desired results cannot be accomplished instantaneously. The process of extrusion has long been applied to the production of seamless lead pipes, and the process is now being applied to the forming of numerous shapes in several different metals, the metal also being improved by the operation.

The force required varies with the metal. Lead in the form of filings can be compressed into solid metal with a pressure of 13 tons per square inch, and with the use of 32 tons will flow like water and obey hydraulic laws. Copper required 33 tons.

Soft and medium steel are readily manipulated by hydraulic pressure, thus shaping large objects from the sheet metal. If the proper time elapses during the operation to allow the molecules to adjust themselves, no internal stress results.

The theory of elastic forces in solids has recently been fully developed mathematically, making, however, many assumptions not fully accepted by all engineers.

The complications of the resulting formula can be best illustrated by the statement that one formula for non-isotropic bodies contains 21 coefficients.

The engineer in active practice at the present rate of compensation can scarcely find time for such mathematical gymnastics.

Such investigations are better suited for those mathematicians who, not content with exploring ordinary tri-dimensional space, plunge into hyper-space of "n" dimensions, study curved spaces,

and pursue the devious ways of non-Euclidean geometry, and non-Archimedean mechanics.

Another difficulty in statics is in the use of dynamical nomenclature, such as moment of inertia, and radius of gyration—not too easy of comprehension dynamically, but far harder to grasp when used statically.

There is, strictly speaking, no such thing as the center of gravity of a surface; but by assuming a very small thickness forming a disc, the idea becomes clearer. The English terms, centroid and "second moment," are less equivocal in the meaning.

The real difficulty in grasping the idea of the moment of inertia as applied to statics is that it is a biquadratic quantity, and as such could only be represented geometrically in space of four dimensions.

The nearest approach to visualization is when it is a case of the moment of inertia of a body about an axis exterior to itself, when you can represent it by a sphere equal in volume to the cubical quantity involved and a line representing the additional factor.

The section modulus being a cubical quantity is more easily visualized.

Even so great a mathematician as Henri Poincaré says that in neither physics or mechanics should we expect that any letter or symbol can fully represent the qualities of matter.

With exterior forces alone there is little difficulty, because it is then a matter of logical system applied to ideal concepts. Fortunately our principal structural material is nearly isotropic, so that we can apply mathematical theories to built-up or rolled shapes under approximately theoretical conditions. Of this the "I" beam is the best example and is a really great invention.

Recently an important improvement has been made by increasing the radius of curvature of the fillet joining web and flange at a point where its combined shear and tensile or compressive stresses are a maximum.

Let us now take up the inner nature of steel. Steel to the layman is a hard dense material of practically unlimited strength. To the man of science it is first a crystalline aggregate, crystals of pearlite, martinite, hardenite, etc., held together by cementite, or a mixture of cementite with uncombined graphite.

These crystals, which are beautifully shown by polishing and etching, vary in size and shape, and furthermore are very susceptible to thermic changes, affecting materially the strength of the steel.

They are held together by their own innate cohesive force, of which we know very little; and fracture may occur by sliding on their cleavage planes, thus splitting into smaller crystals.

These lines of displacement can often be clearly seen on the etched surface, or the failure may occur in the cementing material, the crystals separating, and this is perhaps the more unusual procedure.

Going now a step further into the constitution of steel, we find that the crystals are composed of more or less complex molecules, which in turn are but solar systems of atoms, almost infinitesimal spheres separated from each other by relatively large distances, and moving at incomprehensible velocities. The division of matter is now carried still further and we must imagine the atom as made up very much smaller corpuscles, and these are possibly only vortex rings in the ether, like smoke rings in the air, which mathematically are said to be the equivalent of a solid. We will stop, however, with the molecule as being the physical unit. These molecules are interpenetrated by an imponderable substance of such apparently contradictory qualities as to be practically inconceivable—of almost infinite elasticity, of a density far greater than steel, it is at the same time so tenuous that it offers scarcely appreciable resistance to the motions of the heavenly bodies. Matter, however, is only a sieve with very wide meshes.

Matter is made up of atoms separated by relatively large distances, while the generally accepted idea of the other is that it is a continuum. This will enable us to get the idea of its density. Steel is porous; the density that we measure is only that of particles diffused through this ether. If we knew the density of an atom of any element we could by means of the combining numbers calculate that of an atom or molecule of steel.

The ether is the only really rigid body in the universe.

All of this may seem rather far-fetched as relating to practical engineering, but fundamentally all molar stresses in matter resolve themselves into molecular stresses, and these are probably stresses or strains in the universal luminiferous ether.

The simplest reaction of a beam on a column is only explanable rationally by the intermolecular forces.

The fatigue of metal due to constantly reversed stresses for a long period, has been the subject of investigation, and recently it has been discovered that metals are subject to disease, and even

to contagious disease—the most conspicuous example being tin, which, when attacked, is converted into gray tin, a diseased granular condition in which the metal falls to pieces.

Various metals are also subject to poisoning, and exhibit thus the characteristics of a low form of life.

Crystals always assume the same shape for the same substance and grow, and repair damages quite like living objects.

The action of a rod or bar undergoing tensile stress in a testing machine is an interesting operation—the gradual yielding, the diminishing of cross section and the springing back when the pull is released all indicate the molecular flow of the metal.

When the bar parts the molecules have formed closed systems; the surface becomes covered with a film of air and moisture and the parts cannot be made to again adhere without heat.

This matter of flow comes into play in structural engineering, in the use of long tie rods, subject to transverse bending, which do not have to be figured for bending, as the gradual flow of the metal adjusts the stresses to the sagged shape.

An interesting statical question is the distribution of stress in a beam of rectangular cross-section subject to transverse bending. It is well known that a test to failure would show a greater resistance to tension than that obtained by direct tensible test. This is accounted for by hypothesis that the lateral adherence to the fibers forces upon the fibers nearest to the neutral axis an amount of stress greater than the theoretical stress due to their relative position. At first this was thought to apply only when the beam was tested to destruction and was not of much practical value, but it is now thought to apply also within the elastic limit.

This leads to a curious paradox. A question recently given in a local civil service examination related to the relative strength of a horizontal square beam, placed on its diagonal axis, vertical and horizontal. The question was whether the cutting off of top and bottom angles for 1″ in an 8″ square beam would make the beam weaker or stronger or leave it unchanged as to strength.

It proves to be a fact, mathematically demonstrable, that the beam is increased in strength by the truncation of the edges, within certain limits, which can be ascertained by the calculus.

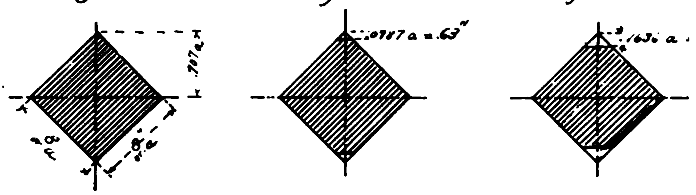
If the top and bottom edges the section, the section modulus increases until the vertical depth removed is equal to $.0787 \times a$. "A" being a side of the square, at this point it reaches a maximum and its modulus is $.1241A^3$.

If more than the above amount is cut off, the section modulus decreases, and when the depth, from the angle removed, is .1636a, the modulus becomes .1179A³. The moment of inertia of the truncated beam is, of course, less than the complete square beam. The gain on strength by truncation is due to a balancing between the effective cross section and the lever arm under which it acts. When the modulus figures for the two cross sections are drawn it is clearly shown.

The increase of strength due to the hardening of steel is believed to be due to the diminished size of the crystals, reducing the inter-spaces and giving more points of contact between the crystals

Tempering reduces internal stresses, but also to a large extent the gain in strength due to hardening is lost. Rolling and re-working disposes the crystals along the longitudinal axis, of course

Fig 1. Fig. 2. Fig 3.



8" Square Mod. .1179 a^3 — Max. Resistance Mod. .1241 a^3 — Equivalent of Square Mod. .1179 a^3

slightly increasing the distance apart of the molecules, but also bringing more crystals, and with the crystals more molecules, within the given cross section. Certain heat changes affect the compos-tion of the cementing material and this affects the strength.

The reaction of a support is a simple balancing of inter-molecular and intra-molecular forces against gravity.

Columns

It is only necessary to prepare a squared paper comparison diagram of the various column formulas, in good standing, to see how empirical is the present scientific knowledge of compressive resistance in members of any considerable length.

A little serious thought will also show the impossibility of a rational formula applicable to the whole range of the ratio of length to diameter.

The column will fail, according to its relative length, by flattening into a disc, by shearing at 45° or crumpling, or by cross-bending, which is the usual form of failures in columns used in structural engineering. When placed horizontally, the compression member as a strut has also to contend with the adverse influence of gravity. Fortunately, within reasonable, practicable limits, the variations are not too great to hope for a practical and rational solution; probably the straight line formula is as good as any.

The dangerous results of excentric loading have long been recognized as regards compression, but this is not as plainly evident in tensile loading.

Fig. 4

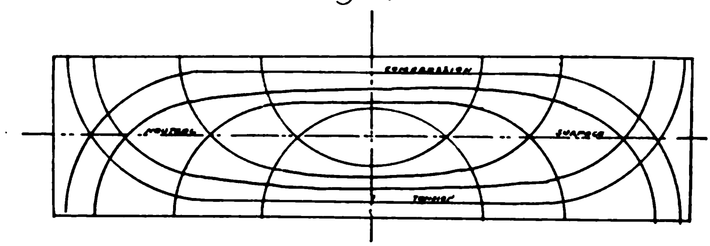
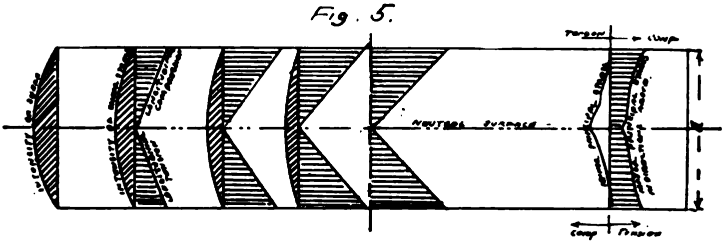


Fig. 5



Any one familiar with the care required to get exactly axial pulls in a testing machine will readily understand the far greater difficulty in getting centric stresses in the practical use of ordinary unsymmetrical commercial sections. The result of these excentric pulls is a tearing action, quite different from true tensile stress, and may be illustrated in a homely manner; by the tearing off of a strip of muslin by a dry-goods clerk.

Framed Structures

In analyzing framed structures we encounter the difficulty that though we treat them as joined structures, they really have stiff joints.

It is sometimes stated that the hammer-beam truss exerts a horizontal thrust, but this is true only when it is improperly designed or constructed; if due allowance is made for bending in the main rafter, at the one point on each side where triangulation fails, it is as safe as any truss.

Tests have been made in England on a full-sized hammer-beam truss set up on supports placed slightly above the ground and then heavily loaded with bricks. It was found by careful measurements that the spreading was no greater than that permitted by the stretching of an ordinary horizontal tie-rod.

Domes

Domes when constructed in the orthodox way, with properly shaped voussoirs, theoretically at least, exerting only normal thrusts, permit of theoretical solution. In the steel dome the possible lines of action are limited to definite predetermined directions. But when we try to analyze the Gustavino dome, now successfully constructed with very large spans, we find our problem indeterminate. No theory of lines of pressure within the middle third can come into service.

Adhesion between the layers of overlapping tiles is evidently the saving feature, giving a very considerable tensile resistance.

Arches

Few arches approximate to the theoretical isolated arch, with its theoretical smooth voussoirs and no friction. Spandrel loadings, especially when these consist of bonded masonry, introduce conditions capable of taking up a large amount of horizontal thrust. The cement mortar of the joints also introduces an element of resistance that must be taken into account. The large arch laid up of hard brick in cement mortar is very far removed from the theoretical arch, and a graphical solution making use of imaginary large voussoirs does not give the true line of thrusts.

Retaining Walls.

The theories of retaining walls leave much to be desired and are in many cases but little better than empirical rules.

Baker says, in his masonry, under this head—"All theories assume that the coefficient of friction in the interior of the earth mass is the same as in the exterior slope; or, in other words, all

theories assume that the coefficient or internal friction is equal to the tangent of the angle of the natural surface slope."

The preceding examples illustrate that most, if not all, theories are logically self-contradictory, either in their fundamental assumptions or in their application to special cases.

1st assumption surface of rupture a plan

2d point of application of resultant ½ above base

3d relates to angle between the back of the wall and the resultant pressure.

Steel Base Slabs

Steel slab bases, now used as distributors of pressure between column and concrete footings, offer a more or less indeterminate problem.

Books on applied mechanics discuss the stresses in flat plates when uniformly loaded and either supported at the edges or secured at the edges, but the slab is a case in which the plate is supported at the center and uniformly loaded.

The problem is quite different from the steel grillage footing, because in that the lines of stress are predetermined by the position of the successive layers of the beams, which are stressed only in one direction.

The conditions are also quite different from those of the reinforced concrete footings, though the theories discussed for the latter offer some suggestions. The most satisfactory mode of calculation would seem to be to first calculate the unit stress of the uniformly distributed upward reaction of the concrete footings; then assume cantilevers of a unit width of say one inch and of the depth of the slab projecting from the four sides of the column base-plate; considering each cantilever as loaded with its own proportion of the unit load, plus its proportion of the amount carried by the corners, the corner load being supposed to be transmitted to the cantilevers on either side. There are, of course, other views of the matter. We may assume radial distribution with the difficulty that if our cantilevers are carried to the center, they have no width, and if stopped at the outer edge of column base, are narrowest at the point of greatest bending moment. As the tendency of the base plate or slab is undoubtedly to buckle rather than bend (that is, to bend in two directions), the question is how much allowance shall be made for this double or right angled resistance. The slab is in reality probably cubically stressed.

We will not take up the question of stresses and strains in mushroom system of reinforced concrete, as the subject is very intricate and is fully discussed in a recent issue of the proceedings of the American Society. The University of Illinois Testing Station has recently issued a report on the tests to failure of reinforced concrete footings. Other indeterminate problems of some moment are the proper size and placing of stiffeners on plate girders, and a good theory for latticing of columns. All formulas now in use assume incipient failure.

In many cases of doubt we can save the situation by adding some steel for good measure; but this is dangerous in gigantic structures in which the dead weight is more important than the live load. The weight increases as the cube of the dimensions, the strength only as the square.

The general tendency in engineering at the present day is towards simplification of structure. The abandonment as far as possible of continuous beams, the substitution of cantilevers in the place of continuous trusses, and the construction of but few double system trusses.

The idea that I have endeavored to bring out is that we should avoid the fallacy of analyzing mere definitions and postulates, assuming that the results correspond exactly with physical conditions in the material. To follow this up would draw us into the metaphysical discussion of nominalism and realism; but, avoiding that, we can easily see that no symbol or set of symbols can fully represent these physical conditions. The necessity of ample factors of safety is therefore evident; as is also the importance of checking by actual experimental tests of materials and structures. I will add a quotation from a recent number of "Engineering," London:

"Common-sense without mathematics will do a great deal, common-sense and mathematics will usually do more; but mathematics without common-sense, what need be said?" The writer speaks further of "illusively exact operations":

"Alas the sprite that haunts us
    Deceives our rash desire;
It whispers of the glorious Gods
    And leaves us in the mire.
We cannot learn the cipher
    That's writ upon our cell;
Stars help us to the mystery
    Which we could never spell.

"If but one hero knew it
    The world could blush in flame;
The sage, till he knew the secret
    Would hang his head for shame.
But our brothers have not read it;
    Not one has found the key;
And henceforth all are comforted
    We are but such as they."

Whenever a natural process is represented by mathematical symbols, it is well to remember that the artificial statement often expresses more than actually obtains in nature; because in the physical world only changes of a certain nature occur. We must, therefore, limit the generality of the mathematical expression.

MODERN INORGANIC CHEMISTRY,
J. W. MELLOR—1912.

"We draw the following conclusions; physics, in place of offering a more precise verification of classical mechanics, leads rather to correcting the principles, considered a priori as rigorous."

Les concepts Fondamentaux de la Science, Enriques, p. 267.
PARIS, 1913.

DISCUSSION

CHAIRMAN.—Mr. Button has given us an extremely interesting paper. I hope you will give it the discussion it deserves.

A MEMBER.—Mr. Button's diagram of shearing stresses in a beam indicated that the shearing stress varies from point in a vertical section of the beam; but the common theory of beams teaches that the shear is uniform throughout a vertical section.

MR. JOHN C. TRAUTWINE, JR.—The common theory of beams, in considering shearing stresses, regards the beam as divided into an indefinite number of vertical slices, free to slide vertically upon each other, but in deep beams it becomes necessary to take account of the fact that these shearing stresses are compounded with the longitudinal (tensile and compressive stresses) with the result that, at each point in the beam, the vertical unit shear and the horizontal unit shear are equal, and that the vertical shear (like the horizontal shear) varies from point to point in a vertical cross-section.

Mr. Button's diagram represents the directions of the maximum unit stresses (both normal and shearing stresses) at the different points in the beam, said directions being tangents to curves, as shown in the diagram.

A steel I-beam or plate girder acts much like a truss, the flanges (like the chords of the truss) taking the horizontal (tensile and compressive) stresses, while the web takes care of the shearing stresses; but, in our modern beams of reinforced concrete of rectangular section, these diagonal maximum stresses must not be ignored.

Mr. Quimby.—Taking these things in inverse order, the matter of truncating the square and weakening it is a fallacy. It is a fact that the section modulus is not as strong as if it had a full section, but that is only because with the full section you get a higher fiber stress, because the extreme fibers are square direct axis; with these truncated portions on you have more fibers to resist. It is a fact that the square is weaker in the diagonal direction that it is in the horizontal direction. If you have a long rod—no matter how you start the bending, if you do not heat it, when it does turn it will bend in the wrong direction. The stress is higher, and you have more fibers to resist the forces.

The trouble with the combination of mathematics and materials is not with the mathematics; it is with the quality of the material, which you never know exactly, and secondly with the effort to make the material resist different kinds of stress at the same time, and then you are uncertain in your combination. You can relieve that condition by testing your beam.

Say you start with a heavy member—a rectangular beam—and you get combinations of stresses which bring in uncertainties. You put in vertical members to take your shear—four diagonal ones if you choose, to take your tension stresses, and you put in horizontal members at the top to take compression, and the bottom to take tension, and you entirely relieve them of the uncertain conditions of stress. The trouble is not with the mathematics—mathematics is an exact science. The trouble is with the application of them.

The matter of steel slab bases reminds me of an interesting observation I made quite recently. The Pennsylvania Railroad has been engaged in rebuilding the highway bridge over Girard Avenue. On a recent Sunday afternoon I saw the bases of the tops of the piers that were under the columns, the columns having been removed. The plates were bent up between the ribs which bore upon them in service; they were permanently buckled up, perhaps as much as half an inch. The interesting part of it was that the top of the cap stone of the pier was shaped to correspond with it. It was Sunday afternoon, and I did not care to mess into the thing then, but when I went down there the next morning to see the columns, they were removed—taken away during the night—and the holes were filled up. I dug out one of the holes and examined the stone, which extended perhaps 8 or 10″ beyond the base plate of the column. There was a depression over the whole area of the base plate of the column base—the rib members are ⅜″ deep, and around the edges—well, the whole line of the base plate was shown in the stone. I found it was a stone much like that which comes from Glenn Mills; it was not hard enough to resist the continual pounding; it was pulverized, and the plate was not sufficiently stiff to distribute pressure enough to prevent that.

Mr. Trautwine.—That was not strictly compression, though.

Mr. Quimby.—Not the wearing away.

Mr. Button's statement that materials exhibit some indications of low forms of life is interesting to me, and I think it is true. I believe that inorganic substances have, to some extent, the characteristics of organic life. I believe, that material, steel, say, is strengthened by exercise just as our muscles are. I believe that it is subject to diseases just as we are, and probably of more than

one kind. It seems to me that corrosion is a disease, and probably, at least in some of its forms, a contagious disease.

In the matter of the base plate of the column, if it had been sufficiently stiff to distribute the pressure over a larger surface, it would not have given way.

I forgot to mention this question of shear, as to the amount of it and the place of set. We treat it as a vertical force unless we are dealing with diagonals. We can carry a shear through diagonals. Any solid member we treat as a vertical force, and we treat the horizontal force as the bending moment, as the horizontal shearing force becomes the horizontal stress. A flange stress is the accumulation of the horizontal shear, but the vertical shear, for which Mr. Button's diagram was made, is the vertical shear, and unless there be regularity in the cross-section, then the vertical shear must be the same and be uniform throughout the member. The effect in that shear, however, is not altogether in a vertical direction.

Mr. Trautwine.—The direction changes at every point.

Mr. Quimby.—Yes. The habit of stress is to go where the resistance is and to take the shortest road to the resistances.

Mr. Button.—When we consider anything mathematically, we are obliged to take things separately. Now, we are in the habit of thinking of steel as a solid thing; but it is not. The shear, the bending moment, the torque, everything is going on at once. It is a combination of all those stresses—none of them can go on separately. The bending or the shear cannot act separately, but as a matter of fact, they all act together and produce this sort of a curve, and the general effect is compression one way, and the other way, tension. We can only get a very dim idea of what does go on with these planetary systems of molecules inside.

Mr. J. C. Trautwine, Jr.—I think the fallacy of our old-fashioned information of that vertical shear going straight through is due to the beam being divided into a number of vertical slices, and I think it can be shown that there is a horizontal and a vertical shear at each point, varying throughout, greatest at the end of the beam and nothing at the span; greatest at the middle of the height and nothing at the top and bottom.

Mr. M. E. Hibbs.—I think we are missing the greatest truth of Mr. Button's paper if we do not realize that after engineers have made their calculations they are apt to sit down and think they have finished their problem.

The Filbert Street viaduct is an example of this and the dimensions are in Mr. Trautwine's book. I made an examination there and found the line of pressure went outside the line of skewback. While Mr. Brown was with the Pennsylvania Railroad there was a crack in one arch, and engineers said those arches would fall down. They were built in 1880 and they have held the largest traffic in the world, and I defy any engineer to tell me how those arches have held the loads that have been placed on them since 1880 up to the present time.

Is there any engineer who would put a single angle up in a column and put it on a base plate and tell me mathematically that everything is O.K.? We had a tank collapse in the city of Philadelphia; we had one angle at the column; the

load was figured at 200 pounds per square inch, and it collapsed. I figured that there was 2,000 pounds stress per square inch.

Mr. Carl Hering.—This subject of mathematics applied to engineering recalls a case in which a number of engineers each worked out a different formula for the draw bar pull in traction; and they included in their formulas all sorts of things factors like head-on wind pressure, velocities, curves, grades, etc., hence included some refinements. Each claimed his was the most accurate. But a fireman of a locomotive once remarked that he didn't care about a head wind, but that when the wind came from the side it made him work much harder. There was a most important factor, therefore, namely a wind from the side, which had not been thought of or included by the constructors of these formulas.

Another instance, which occured at a meeting of this Club, is that of the straps around a wooden stave pipe. These straps are put on under great tension. The water pressure in the pipe then puts an additional tension on the straps, and the question is whether this additional tension has to be borne by the straps. The speaker of the evening said that it did. As a matter of fact, that is not correct. Up to a certain limit the straps will not be stretched any more after the pressure is in the pipe than they were when they were put on. That discussion was published in our proceedings, and anybody interested can find it there. It shows how easily we can be misled by applying mathematical formulas, without careful judgment.

PAPER NO. 1133

COLOSSAL WASTE DUE TO BAD MUNICIPAL ENGINEERING

By BERNARD J. NEWMAN

Read November 1, 1913

It may be an old fashioned idea or it may be new, you can characterize it as you will, but the fundamental purpose of all municipal government and the activities set in motion by it is the benefit of the public. Social instincts draw men together in towns and cities, economic laws set the limits of their personal freedom of choice in the manner of living there, cummunity interests tend to centralize their form of government, but the indisputable fact is that the welfare of the public as a whole alone justifies the expenditure of public funds, the size of the tax rate, as well as the regulations, call them laws or ordinances or Department rules, that control their conduct toward each other and toward the whole. I am taking this as a thesis tonight, though I have hidden the subject under the more sensational title of "Colossal Waste Due to Bad Municipal Engineering."

There are wonderful possibilities in this more sensational subject. For example, one might treat it along the lines of defective engineering caused by graft: the leakage of materials connected with the construction of a Filtration Plant. Or one might expose the defects of construction of a type similar to that mentioned in connection with the construction of the concrete walls at League Island Park, or the Passyunk Avenue Bridge, or the N. E. Boulevard. But the waste to which I refer is not centered in the graft extracted from the performance of the improvements themselves. This latter is valuable to some parties for campaign material or to the newspapers for sensational headlines to stimulate larger sales of special editions. Occasionally it is valuable to shock prominent citizens into voting, but it has no place in this analysis.

What I refer to tonight are the municipal plans for the physical city together with the additions, alterations and amendments

placed to them from time to time, without taking thought as to how such plans are related to each other or to the whole, or how they act upon the people who inhabit the physical city, whether the amounts apportioned for them are, as compared with city needs, apportioned equitably, or whether they are apportioned without vision and, hence, are unbalanced; whether they tend to develop the best living and working and pleasure conditions for the people, or whether they are designed to yield a profitable return for special interests whose invested capital and profits might be jeopardized or enhanced; and lastly, whether they are projected in the light of modern scientific knowledge, demonstrating the effect of environmental influences upon public health, morals and comfort.

In all this, the central figure is man. It is he that is the object of consideration, and for his welfare are all things justified. A peopleless city is valueless. The cliff homes of New Mexico cannot stir up an appropriation from Councils (though perhaps they might get into an appropriation bill in the State Legislature). No one thinks of improvements in connection with them because there are no human things living there to give an excuse for the projection of the improvements. In Philadelphia matters are different. If an appropriation is asked for water mains it is because such are proposed for utilitarian purposes; if sewer pipes, that they may be of service. If streets are laid out and built they are for use. If parkways and boulevards are projected, the only justifiable excuse is that they may facilitate traffic or become objects of beauty and pleasure for the community. The same is the case whether it is a new public library, art museum, convention hall, high school or what not. The justification behind them all is that they minister to some public use, answer some public need.

In the consideration, therefore, of municipal improvements the important question is, in how far do they benefit man and in how far do they interfere with his best interest? If they are for him, then there is only one consideration of prime importance: namely, do they help him or do they hurt him, either by withholding from him other and more important improvements or by fastening upon him problems he did not previously have, and which in themselves seriously handicap him? This is not a radical requirement though it is fundamental, and in reality furnishes us with a measuring rod whereby we can tell the real value of municipal projects past and future.

Making use of this measuring rod, let me place before you certain municipal projects that have been and still are costly. We will begin with the street lay out. When Penn planned the city, he adopted the checker board system; large squares with deep lots; narrow streets, save in exceptional cases where, as with Market and Broad, he made wide thoroughfares. Here and there was a radial street, but the whole had little resemblance to other than the ordinary straight layout. Upon these streets houses were erected so that there might be "a wee bit of green grass" in front and back. Time, and the influx of population, and the wanderlust that has mitigated the development of the ancestral hall in this country, all became factors in changing the earlier developments in the character of their occupancy. The "first families" who settled there moved farther out as the population became more numerous. Land values increased. Taxes were levied on properties intended for dwellings at rates beyond any possible yield on a business basis. One of two things had to be done. The houses had to be diverted from their former use as single family homes to multiple homes, or the extra land in the rear had to be developed so as to return an income. The City had no system; laws governing the subdivision of land were not known. Hence the large lots were opened for building. In some instances the owners cut through a street or streets, portioning the blocks into two or three smaller blocks. These new streets were often joined by cross streets none of which were over 30 feet in width, while many were only fourteen feet wide. Of course houses were built upon all and a congestion of buildings created. In numerous other instances, however, these streets were not cut through. The different owners simply used their back lots and erected the small alley house of which we have so many thousand. Some of our city blocks in the old areas have from 25 to 50 per cent. of the houses wholly within the block and without any street frontage. With this development established in hundreds of blocks and with thousands of small houses having one room to a floor and being three floors high, with no yards, often only a tiny alley from four to six feet wide, at times not even this, but eight or ten dwellings facing a common court, the congestion of population to the land increased. Of course the type of population that would rent such abodes was lower in the economic scale than that which would rent the street houses, and the problems of public

health and public morals were thereby intensified; to what extent I will point out later.

We, of this city, are fond of contrasting ourselves and our conditions of living with other cities, and always to our own favor. We breathe many a sigh of relief that we are not as New York is. Fortunately, indeed, for us we have not New York's tall tenements. *Nevertheless, we have congestion of population and building congestion that destroys privacy* and assaults our poor in as many vicious ways as do the tenements of New York. Remember the width of our streets in the older parts of the city, then remember what I have said about the subdivision of the blocks, the lack of yards, the alleys and courts. The waste here, due to bad municipal engineering, is economic as well and civic. "The river of national health must rise from the homes of the people and from each individual home," says Dr. Richardson, the English specialist. If the home is lacking in the fundamental essentials for health, that is, proper ventilation, sanitation, living and playing space, if it is overcrowded, if the light is poor so that the occupants are living in gloom all the day, if there are dozens of other homes of like character nearby, what chance has any one of them to become a source of purity or strength? It is absurdity reduced to its most absurd limits.

But there is another side of this. Such subdivision of the land so as to build back lot houses *has been legally stopped. The laying out of streets on a narrow basis without any precautions* to control the use of such streets or the permanency of the type of occupancy is still going on. The minimum requirements for the open areas in and about buildings has been changed so that instead of permitting a family to share an alley with the adjoining families for a playground, the law now says each house shall have at least 144 square feet of open space, but the builder can put it in a strip running along the side and back of the house in any width he wishes Some have made this strip five feet wide. The neighboring owner has built clean up to his property line, thus producing as vicious a type of an alley as anything perpetrated in the olden days. It is entirely feasible to house a population, under our present building code, of 300 people, in small dwellings, to the acre, including streets in the estimate. If recourse is made to the tenement type, building only four-story houses, we can easily create a density of 1,000 people to the acre. *These evils are visionary, do you say?*

I imagine those early settlers who were told they were misplanning the city also said the evils we now have were visionary. We do not know the results, we only know the possibilities. If the possibilities are bad, the engineering that planned them is faulty. For if I understand the science of engineering, it is to enable projects to be accomplished without mistakes and for beneficial results. In short, we have not today learned the lesson of the past, but are blindly rushing forward to the reproduction of similar evils in the future.

As I started to say a while ago, there is another side of cost to all this changing in the character of neighborhoods and of the occupancy of buildings from a higher to a lower grade. It brings its burden upon the rates in the increased taxes, the depleted civic interest, the debased manhood and citizenship, but it also necessitates economic costs few people consider. Narrow streets with increased congestion of population means increased use of streets, larger demands upon the drainage system, increased facilities for water supply to accommodate the people of the neighborhoods unless we are satisfied to give only one spigot to a court of four, five or fifteen houses. Under normal needs with the increase of population there comes an inadequacy of municipal facilities. All the provisions previously installed in these lines have to be enlarged or duplicated. If this is not done, there is an inadequate service. This is well illustrated in the water supply for southeast Philadelphia, where, during portions of the day, the pressure on the mains is insufficient to force water to the third floor of some of the tenements. Moreover, there is an additional extravagance. Traffic conditions change. The amount of it overflows the space for it. The speed is reduced; the danger from it is enhanced. Time is money in business and especially where labor is purchased. If it takes an ordinary dray an hour longer to deliver its load an account of the heavy traffic in the streets that there were not intended for other than light traffic, then the cost of that delivery is increased ten per cent. If it takes the grocer, or any other tradesman, a half-hour longer to get about because of the street conditions it adds that five per cent. to the cost of the goods, in the figuring of which delivery charges are considered. Then again, the congestion of traffic caused by the congestion of population intensifies the wear and tear of the pavements, for it concentrates instead of spreads the burden of it, and the repair

gang is called in more frequently. You may say these are small items, but in every budget it is the small item that ordinarily escapes and that makes the bills soar. The point I am making here is this. With the failure of the city to lay out its streets on a scientific basis and with the attendant failure to regulate the changes in the character of the occupancy of the neighborhood, these evils creep in; and the cost to the city attendant upon the transition fastens a burden upon the people in added taxes, in economic prices, in health, morals and personal fitness.

It would seem, therefore, that the lay-out of the city streets, affecting as it does the economic use of the city blocks, would *be a proper field for scientific municipal engineering*, and that the mistaken plans now fixed by ordinance over large and undeveloped areas within the city might be subject to special study and revision; while, at the same time, the area requirements for open space about buildings should be changed so as to protect the future against the duplication of the mistakes of the past.

Then, again, and let me cite these rather rapidly, there is the need for an underdrainage program for the city. To meet the needs of a city growing about 25,000 people a year there must be a definite plan so as to anticipate developments and to prepare the streets below the surface before the street above the surface has been completed. How inadequately this has been done is illustrated by the simple statement that there are approximately 42 miles of streets in the older parts of the city that are without sewers. When you remember that nearly all of these are wholly or partially built up and that the failure to lay pipes is responsible for two of the most pernicious of nuisances, surface drainage and the privy vault, you will appreciate the waste in human life, health, and well-being thus caused. For be it remembered that, as Mr. Vogleson, of the Health Board, says, "The death rate of the city is directly related to its sanitary condition." E. F. Smith, in an early book on the subject, calls attention to the fact that when a city has been underdrained the death rate has dropped and never again climbs to the former heights. If this is the effect of underdrainage on a city as a whole, it must likewise be the effect upon the city in all its parts. Where the lack of proper drainage exists, the city is to that extent exposing the people there to disease risks. The skeptic can easily assure himself of the truth of this if he will go into the obnoxious conditions produced by the privy vault which

Smith, in his "Filth Diseases and their Prevention," states their pollution of the air is a chief means of spreading some of the most fatal diseases. It is not a far cry from the filth and the disease germs in the vault to the same within the home when fly breeding time is with us.

Further, when sewers are laid in the older areas there seems to be no definite plan. Several blocks will be without drainage and yet ordinances will be introduced into Councils for sewers that skip a street or two and provide pipes for alternate blocks, with the result that one row of houses can underdrain but the next row cannot. The underdrained row will still have to put up with the filth caused by the surface flow and the vaults of the row not underdrained. Moreover, there are many streets that have been opened for a score or more years but the beds of which have not been dedicated, thereby delaying the placing of sewers. A full work for the city would include a thorough study of conditions so that all occupied streets should be placed on the city plan; all streets should be legally opened; all legally opened streets should be provided with sewers; and all streets toward which building operations are tending should be opened and sewers laid at the time so as to reduce the actual cost of the work to the city. We are going to see a stimulus in new buildings in new areas when the subway goes in. Advantage should be taken of this opportunity to prepare the section beforehand.

Delayed improvements are always more expensive. Especially true is this when the improvements are of a sanitary character and their delay affects public health or augments the processes of deterioration that are constantly active in the physical life of the community—processes, by the way, that seriously influence the moral and civic life of the people.

Without attempting to enumerate the various forms of public improvements that have their reflex action so injurious to man when they are not planned with an eye to their possible effect, let me cite a few that are usually incompletely planned and result in the creation of detrimental conditions or intensify such conditions when they already exist. We all favor parks and playgrounds and boulevards. They are essential to the development of a city. Yet we have provided them here in Philadelphia as if they were an entity in themselves. The situation along the line of the proposed parkway is typical. Here the city has condemned dwellings

of all sorts and conditions. It has removed some that were exceedingly bad and others that were good. At a modest estimate it has taken the homes of from 1,500 to 2,000 people. For those of comfortable circumstances the removal did no harm for they could find plenty of houses as good as the ones they had occupied for rent or purchase. But the poor were sent into the congested sections to intensify the congestion. They had to go where they could get rooms for the rent within their means. Thus the city took the homes of the poor to make a fine boulevard, but it did not consider the added problem it forced upon these poor and others in similar circumstances. What I am seeking to emphasize here is that a satisfactory city program will never contemplate improvements without counting the cost and making provisions for those whom the improvements displace. The renting of houses is subject to the law of supply and demand and the demolition of any arge number of homes without the erection of others to replace them throws the balance over against the man who pays the rent. This means eventually increased rents, smaller apartments for the very poor and all the evils that attend overcrowding.

In like manner all improvements of whatever nature have their effect for good or for evil upon home life. The location and size of factories, store houses, terminals, wharves and docks, steam railroads, transit lines, tunnels and elevated, centers of commercial life, all affect the environment of man and determine for him to a large extent the health opportunities of his home.

This survey has necessarily been hasty. I do not pretend it is more than an index of causes that rightly co-ordinated develop a community by being considered as separate units without relation to each other and to the dwellings of men produce the evils we find so plentiful in all our large cities and all too plentiful in the city of Philadelphia.

You ask what is the cost of bad housing to the people of Philadelphia? I very much fear I would have some difficulty in answering that question off-hand, for it would require an amount of special research that my time just now would not justify. You see we would have to approach an answer from the health side, the economic side, and the moral side. So far as I have been able to ascertain no one has gone into any of these aspects of housing of Philadelphia so as to be able to give an answer at all approximating accuracy. It has been worked out to a limited extent, just enough

to know the cost is tremendous; but the full sum has not been determined. Take, for example, the health side of the question. The last published reports indicates that there are approximately 9,000 preventable deaths a year in the city of Philadelphia. Now we know a preventable death is a death from a disease that should not have had a foothold here; that is, the disease is a so-called filth disease. It is common knowledge that filth diseases are preventable, and they only continue because communities permit conditions to exist that cause them. Get rid of the conditions and the disease will in a large measure be eliminated. Take tuberculosis as an instance. How long would it continue to be a scourge if air and sunshine were let into all the homes of the people? And if the houses that year after year go on making their victims were cleansed out thoroughly or else vacated and forced to stay vacated until they were thus cleaned? When our Commission was preparing the Heidinger Housing Code, we made some studies of tuberculosis records. We found one house from which, during the last five years, fourteen cases were reported. Many houses had a record of seven, eight, or nine cases during the same period. These were all new cases and in different families. As is to be expected, these records were taken from the old parts of the city where the houses are built more closely together and where sunlight and ventilation are often luxuries in alley homes. Some years ago Dr. Flick made a more extensive study of tuberculosis as it is related to the housing conditions of the people, and his published records show the frequency of occurrence of this disease in certain houses to be abnormally large. Approximately, during the past five years 3,000 people each year, in Philadelphia, have died from this one disease. There are now at least 10,000 people with well developed cases in the city.

It is unfortunate that very little attention has been paid to the collection of exact data upon which to make an accurate study of the effect of conditions upon public health in this city. The Health authorities have not gone into this analysis and private persons have not the facilities to do so. In any scientific program for the protection of public health such data is necessary, for without it the efforts to stamp out contagion must necessarily be more or less of the nature of guess work.

Equally important also is such data as an aid to law enforcement. When scientific studies are made tracing the relationship between

cause and effect so that even the greenest novice of a juror or magistrate can see it, the excuse for noxious conditions to remain is removed. Other cities have made such studies and it is upon their work we have to depend for the scientific statement of the consequences in ill health from bad housing.

Data has been tabulated of the general effect of city life upon public health both in England and in Germany. Horsfall, in England, states that only 1,000 Manchester men out of 11,000 examined were physically fit for the army at the time of the Boer War.

Prof. Pasadowsky, in Germany, reports a study of 621,210 German soldiers and sailors. Notwithstanding the enforced service of all young men in the Empire physically fit for duty, yet two-thirds of the enrollment of both divisions came from the country districts. This difference becomes even more strikingly pronounced when it is remembered that there are 5,000,000 more in the cities than in the country districts.

Measured by army standards of physical well-being, the effect of congested community living, under adverse circumstances, is wearing on men. But let us bring this record down to the areas in which the large proportion of bad housing conditions are to be found, and see what we find. Overcrowding or congestion is a large factor in increasing deaths. For example, Dr. Newman, Medical Health Officer for Finsbury, reported the ratio of deaths to 1,000 population in four-room houses, in his district, to be 6.04, while the ratio of deaths for one-room houses was 39. That is, under the more sub-normal, congested living, over six times more persons died each year than in the more normal conditions. In Glasgow, a few years earlier, figures not quite so startling were unearthed. The one-room homes had a death rate of 32.7 per 1,000 while the four-room homes had only 11.2.

Then again, take the records of the houses as regards block ventilation. A study of 13 cities in West Yorkshire, England, showed an average death rate in houses open on two sides to air currents of 15.51 per thousand, while those houses built back-to-back had a death rate of 17.94 per thousand persons. The record for pulmonary diseases, excluding phthisis, was equally enlightening. Here the comparison was 3.6 in the well ventilated houses and 4.44 in the poorly ventilated houses.

These figures are especially interesting in that in this city we

have many back-to-back alley houses improperly ventilated and lighted. The contrast for the same disease in the crowded houses in London is likewise extreme. Thus one-room houses have a rate of 3.4 as contrasted with 1.4 in three-room houses. While for other respiratory diseases the rate for the one-room is 8.3 as compared with 2.9 for three-rooms.

Perhaps as good an illustration of the handicap bad housing puts upon the public is presented in the figures of development of the school children in Glasgow. In this study the school authorities took records of 78,857 children between the ages of 5 and 18 years. Boys living in one-room houses weighed 52.6 pounds and were 46.6 inches high, while those in four or more rooms weighed 64.3 pounds and were 51.3 inches high. The effect upon the girls was even more striking. Those living in one room weighed 51.5 pounds and were 46.3 inches high as contrasted with those in four or more rooms who weighed 65.5 pounds and stood 51.6 inches high. The school authorities, commenting on these figures, say the difference in so many homes cannot be due to accident and put the blame squarely upon the environmental influences that are so bad.

Now it may be claimed that there is a multitude of other causes producing these defects, and housing is not so great a factor as it would at first seem. It is not the only factor. In other words, the chances for a baby to live were more than twice as good amid the good housing conditions as amid the bad. Even more effective a presentation of the differences is found in the Liverpool figures. In one large area where the old back-to-back houses and rookeries were torn away and, in their place, 2,663 new houses were built with opportunities for light and air afforded for each room, the death rate declined from 60 to 27 per thousand; tuberculosis from 4 to 1.9 per thousand; typhoid fever, from 1,300 cases in 1896 to 200 cases in 1911. The change was not due to a new population moving in, for over 70% of the old population were rehoused. In Glasgow, where a similar rehousing took place, the death rate declined in the new housed areas from 43.7 to 26 per thousand. Similar testimony from many sources can be cited and can be sifted to trace the responsibility to bad housing.

The point of it all is simply this: Are we, as citizens, intelligent enough to work for public health along scientific lines? Or are we so short-sighted in our health policy that we are content to

go on caring for and curing the victims while we neglect the causes that produce them? Justice Hughes once said it was foolhardy to keep on increasing appropriations to care for the victims of bad housing while we overlooked the conditions that produced them.

What we need in Philadelphia is a constructive program that will eliminate present evils and prevent the development of new areas along the lines of past mistakes. Patchwork programs and temporizing policies should be relegated to the incinerating plant.

It might be difficult just now to demonstrate to Philadelphians there is any connection between bad housing conditions and sickness and a high death rate. It is commonly known to sanitarians that the sanitation of Philadelphia, in certain wards, is especially bad. Until the past year the death rate for the city was very high. In 1912 it dropped to 15.22 per 1,000, and in the minds of some people this was proof positive of the falsity of the statements about the insanitation prevalent. As a rule, the death rate for a single year is a mighty poor barometer of the actual health conditions, so many factors enter in to make the mercury go up or down. We did have a low death rate last year, but so did other cities in the country. Out of 36 other cities of over 100,000 population 23 also reduced their rate, some as high a reduction as 2.1 and 2.4 and 2.63 per thousand. Exceptional conditions favored the public and reduced for the time the toll levied on them by the insanitary areas. Even then, as a matter of fact, out of 45 registration cities having populations of over 100,000, reports from which have come to our office, 23 had lower death rates than Philadelphia and 21 higher rates. Among the cities having a lower death rate were Chicago and New York, although both have a larger population. Although, therefore, we dropped lower last year than ever before in our rate, yet we need not become too self-satisfied. We are still 24th from the top on the list of large cities, and approximately during the year 8,000 deaths occurred from diseases that are scientifically known as preventable. If these preventable deaths were from any cataclysmic cause we would be horrified. "If such a calamity occurred in a single day and it was preventable," to quote a well-known insurance society, "and was not prevented, the dereliction would be regarded as a crime." "Is it any less a crime," they add, "that it takes 365 days instead of one day to destroy these lives?" Not all, by any means, of these deaths can be laid at the door of bad housing, but without doubt a large percentage

can be so charged; for from centers of infection, circles of infection radiate, and who knows to what boundaries the outermost circles go? Mediums of transmission are many, and while the ulcers last none are safe.

I have perhaps dwelt upon the health aspect of bad housing a little too long. It does not follow that all such deaths are due to environmental influences; but in part they have a causal relationship.

There is another cost we are paying, and this can be spoken of in terms of morals. You are familiar with the statement made by juvenile workers that 90% of the children that enter the children's courts come from bad environmental influences. We made a study of the effect of the alley house, the lack of play space and the insanitation of one congested block and we found that all the alleys sent their representatives to the children's court in 1910. In the block there were 1,106 people, and 629 arrests occured in three years. This means one arrest each year for every four people, leaving the babies out. The data collected from Liverpool showed that the number of arrests dropped 50% although the new housing scheme took in 70% of the people.

It stands to reason that the very condition of the overcrowding does not allow the play instinct of the child to get an opportunity to express itself in ways that are safe while the irritation so often shared by all adults when expressed in the crowded court lead to frequent encounters that result in transgressions of the law.

The side that is the most pernicious because perhaps it cannot be measured is the breakdown of the morals of the young people attendant upon their living so many in a room. The young girl cannot preserve her maiden reserve when she must occupy the room with her parents and the ever-present boarders. When whole families live, sleep and cook, entertain their friends, tend their sick and bury their dead from the one-room apartment there is little chance for morality to be conserved or developed. Is it any wonder that under the stress of living with the temptations that assault the poor the moral standards fall and practices are indulged in that are classified by society as immoral?

But the economic loss is the greatest. The individual pays, and so does society. The individual pays in the loss of ambition and vitality, the loss of wages, the doctors' bills and the druggists' bills and many similar denials that lead to poverty in its worst

forms. Society loses in the bills it has to pay for the care and prevention of the spread of contagion and the victims of such. Do you realize that in five years from 1907 to 1911 there were 109,066 cases of contagious diseases from six of the 27 diseases classified by the Board of Health as contagious. Of this number, 31,375 deaths occurred. I have not had time to determine the number of cases of such diseases cared for by the city and private hospitals as charity cases, but I know that the average cost for a number of years to the city for hospital care is $2.00 per day per patient. There is added to this the annual cost paid for the work of the Health Bureau. For the child sent to the reformatories, etc., there is a weekly cost of $3.00 per child. When you realize that we are 20 centuries almost away from the date Christianity is supposed to have begun and the far longer period civilization has been at work upon the race, it is a sad commentary upon the work done that we need larger hospitals and asylums and poor-houses, larger police force, larger and more courts, judges and all the kindred staff called into being by the manner of living of men. Not all, by any means, is traceable to bad housing but this plays a large part, in that environmental influences are at play to mould for good or ill those who come within its sphere. If the figures of English statisticians are correct there is an average of 20 cases of sickness for each death and 20 days' loss of work for each sickness. On this basis the economic loss to Philadelphia for the 8,000 to 9,000 lives needlessly sacrificed amounts to from four to six millions, a loss that is increased when it is remembered that with it goes the drain upon public and private charities for the care and upkeep of the families thrown by such sickness over the cliffs into the chasm of poverty.

I do not intend to appear a calamity howler in this matter, but the conditions are here and in every city. They are the consequences of a lack of a community program. Such a community program is readily drafted. It needs the attention of men of your profession. I can best let my last remark to you be a repetition of a question asked of me by a poor man in a southern ward: "What are you going to do about it?"

DISCUSSION

Mr. Trautwine.—Mr. Newman has not only shown us existing conditions, but he has incidentally shown us how those conditions come to exist, and has enabled us to appreciate some of the difficulties which oppose their betterment.

The crowded conditions of our city blocks, in the older parts of the town, show what inevitably resulted from the nearly unrestricted individualism which existed in the days of a century and more ago. Then it was "every man for himself, and the Devil take the hindmost." Political economists insisted that we ought to have the least possible government; so the government restricted itself to efforts to maintain order, and left the individual in almost perfect liberty to do as he pleased with "his own."

Today we are beginning to realize the force of a remark, made centuries ago, to the effect that "no man liveth to himself alone"; and we are hardly likely to see, in the newer parts of the town, a repetition of the process which created the slum conditions found in the older portions and so forcibly illustrated by Mr. Newman's slides.

Mr. Newman put to us a question which had been put to him by one of the denizens of the unsanitary slum district: "What are you going to do about it?" I submit that there is not very much that we, as a body of engineers, can do in the premises. The conditions described by Mr. Newman tend to perpetuate themselves. Slum surroundings breed slum people and slum voters, who fall an easy prey to the so-called "politician," and who are hopelessly incapable of appreciating a general benefit, and still more incapable of wishing to be taxed in order that betterment should be brought about. We thus travel in a vicious circle. The slums breed slum people, and the slum people maintain the slums.

Well-to-do people have always been ready to maintain that the poverty of the poor man is the poor man's own fault; that, in this glorious country of ours, no one need go hungry; that if anyone suffers want it is a sure sign that he is idle or intemperate, or both.

Granted that there is something of truth in this, Mr. Newman very pertinently asks: How can you expect, from creatures bred under the slum conditions which he has shown, the high moral fibre, the inflexible sobriety, the untiring industry, which characterize the happy denizens of Rittenhouse Square?

But we are beginning to realize that for us the important question is not "whose is the *fault?*" but "whose is the *misfortune?*" We pharisaically say: "If a man will drink, and won't work, let him take the consequences." Most just, and not unsupported by Scripture. And it might be all very well if "the consequences" could be confined to the culprit; but even jailing him will not do this. As a block of tinder-box houses is a fire menace to its environs; so the slums are a menance to us all. The manure heaps of the slums threaten the health of the rest of the city. Their hordes of easily purchasable voters keep "politicians" in power and render our municipal administrations inefficient and our public service poor and costly. We *are* our brother's keeper.

Mr. Henry Hess.—I must dissent from Mr. Trautwine's condemnation of the individual and from his picture of existing conditions as constituting a vicious circle. The hope of the future is in the development of the individual. We are traveling not in a vicious circle but in an ascending spiral.

MR. TRAUTWINE.—I entirely agree with Mr. Hess, and I regret that I expressed myself so unskillfully as to cause him to misunderstand me. I have the greatest faith in the human individual—if he is given half a chance, and I heartily second Mr. Newman's plea that he be given a chance.

And I gladly accept the amendment, substituting "ascending spiral" for "vicious circle"; but pictures such as Mr. Newman has shown us lead us to wish that the spiral might ascend a little more rapidly.

PAPER No. 1134

THE HUDSON RIVER CROSSING OF THE CATSKILL AQUEDUCT

BY RALPH N. WHEELER

Read December 6, 1913

I have been asked by your committee to describe some of the interesting features in connection with the location, construction and operation of the Hudson River tunnel of the Catskill Aqueduct. So much has been written, in the engineering publications, the popular magazines, and the newspapers, about this particular part of New York's additional water supply, that there is little new matter to present, except possibly as a progress report. In this paper special consideration will be given to the location, construction details, the special work at the top of the East shaft and the unwatering operation.

Those who desire a complete history of the Catskill project, the first development of which is now nearly finished, are referred to Mr. Lazarus White's book on "The Catskill Water Supply of New York City," published by Wiley. Mr. White has been connected with the work since its beginning, and is therefore eminently qualified to write its history. His book contains as an appendix a very complete list of published articles on the engineering features of the Catskill Water Supply.

In this paper rather free use has been made of data from a paper prepared by former Department Engineer Robert Ridgway for the Engineers' Club of Northeastern Pennsylvania. In addition, much useful information has been obtained from Mr. White's book.

THE CATSKILL PROJECT

A brief description of the Catskill Water System may be of interest. The City of New York contains a population of approximately 5,200,000, and consumes about 500,000,000 gallons of water daily. The supply for the boroughs of Manhattan and

the Bronx, something over 300,000,000 gallons daily, is obtained chiefly from the 360 square miles in the Croton watershed in Westchester and Putnam counties. The development of this shed was practically completed with the construction of the Cross River and Croton Falls reservoirs. Anticipating the need of an additional water supply, the legislature in 1905 created the Board of Water Supply of the City of New York, with power to decide on the new sources and construct the necessary works for bringing the water to the city. This board organized in June of the same year, and appointed Mr. J. Waldo Smith its chief engineer. Under his able direction, investigations to determine the new sources of supply were immediately started, and in the following October he presented a report, which was adopted by the board and the city authorities, recommending the water sheds of the Catskill mountains. These sheds include about 900 square miles of area, and were reckoned to be good for a supply of at least 660,000,000 gallons daily.

There are four water sheds to be developed, those of the Esopus, Rondout, Schoharie and Catskill Creeks, together with those of several small subsidiary streams. Only one, that of the Esopus, which is considered good for a supply of 250,000,000 gallons daily, is being developed now; the others will be added as needed. It was decided to build the aqueduct large enough to care for 500,-000,000 gallons daily, as this would be more economical than to build a smaller one now and another later. The estimated cost of constructing the necessary reservoirs in the watersheds and the aqueduct from there to the city line, together with a large storage reservoir and equalizing reservoirs nearer the city, and the distributing trunk aqueducts to the five boroughs, is about $200,000,000. Contracts amounting to about $97,000,000 have been let to date, these covering practically everything except pipe lines to Staten Island and minor structures. Construction work to the value of over $76,000,000 has been performed and the work from the Ashokan reservoir to the city line is practically completed with the exception of Kensico and Hill View reservoirs. Work is now in active progress on the city tunnels and the reservoir on Staten Island.

Fig. 1, p. 182, Vol. XXVIII, No. 3, of Proceedings of The Engineers' Club of Philadelphia shows the new and old watersheds, aqueduct line, etc.

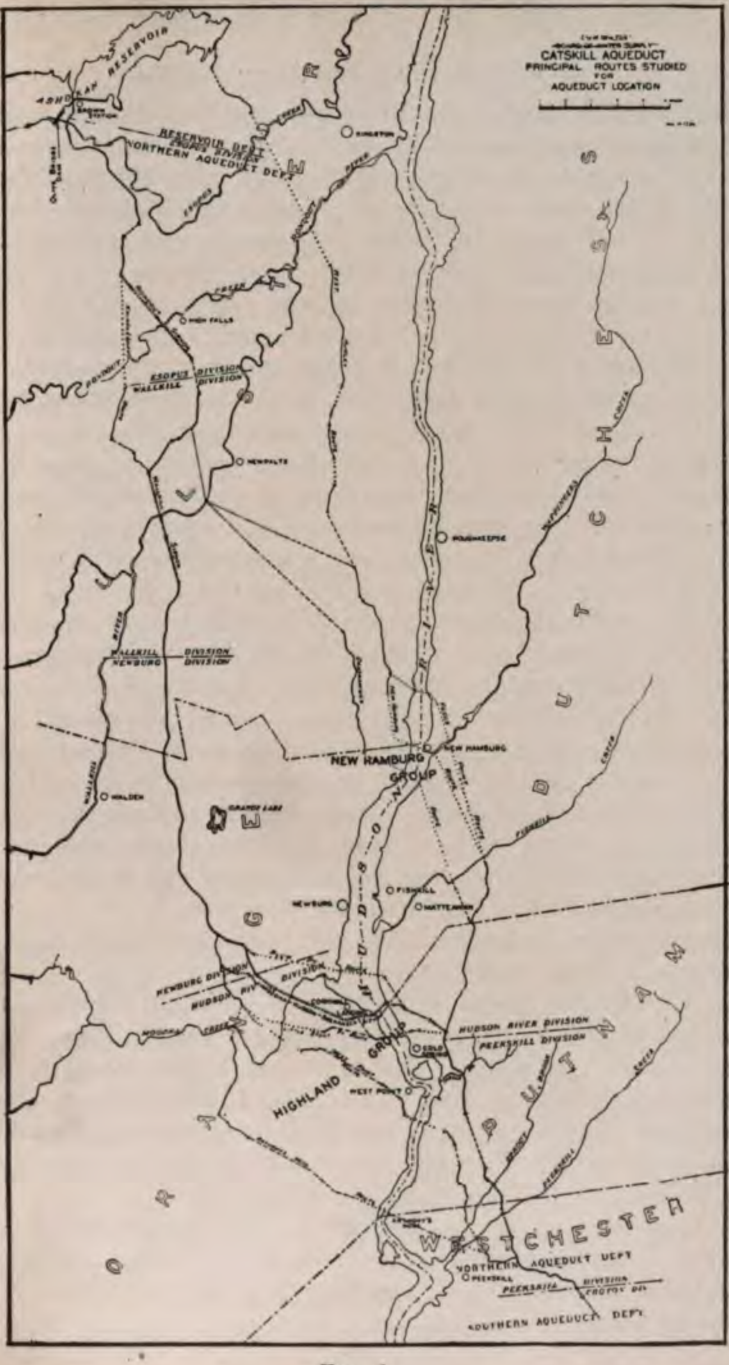


FIG. 1.
Routes Studied for Catskill Aqueduct Northern Aqueduct Department.

Hudson River Crossing—General

Fig. 1 shows the Hudson River and the various lines investigated for the crossing and its approaches. These investigations covered a stretch of river about 22 miles in length from Pegg's Point on the north to Anthony's Nose in the Highlands on the south. It will be seen that many lines were investigated, and that a change from one to another affected not only the river crossing itself, but the land approaches as well. Such change from the extreme north to the extreme south crossing, for example, would in turn modify the location of about 40 miles of aqueduct. In considering the problem due weight had to be given, therefore, to the land conditions. When the studies were first begun the northerly routes, called the New Hamburg group, were more favorably considered than the southerly ones in the Highlands, because it was then planned to draw the water from the easterly end of the Ashokan Reservoir, and a northerly crossing meant a shorter total line. Later, when it was decided to divide the reservoir into two basins, it necessarily followed that the headworks of the aqueduct must be located at the dividing weir between the basins. This threw the starting point of the aqueduct farther back into the country. At the same time investigations for the crossing of the Rondout and Wallkill valleys showed the advantage of locating the aqueduct farther up these valleys to secure better rock conditions. These developments brought the more southerly, or Highland, routes of the river crossing into greater prominence, and it was likewise shown that the adoption of one of them would mean a substantial saving in construction cost.

Several types of construction were considered in connection with the crossing, among them:

1. A bridge, the minimum height of which would have been determined by the War Department, probably not less than 135 ft. above mean high water. The maximum height would be the hydraulic gradient which at Storm King is about 410 ft. above mean tide. The water, or live load, to be carried by this bridge would be very great; far greater in fact than the live load carried by the great bridges over the East River.

2. Cast-iron or steel pipes laid in a channel dredged in the mud bottom of the river. These pipes would be of the largest size practicable to manufacture, transport and lay, and several lines would be needed for the purpose.

3. A tunnel driven through the mud bottom of the river similar to the transportation tunnels under the East and North rivers in New York City, this tunnel to be driven necessarily under compressed air at a maximum depth of about 100 ft., water to be conveyed through it in steel or cast-iron pipes. It is probable that two tunnels of this type would have been needed.

4. A pressure tunnel deep in the rock floor of the river, similar to the pressure tunnel hereinbefore described. A careful study of the problem showed this type to be not only the most economical, but the one that would afford the greatest assurance of durability and safety. If rock could not be found at a reasonable depth, the second or third methods could be used.

Among the desirable features for the river crossing by means of a pressure tunnel were a narrow channel, a shallow bed rock gorge and good geological conditions. Generally speaking the channel was narrower and the bed rock gorge was shallower on the northerly lines. The geological conditions, however, favored a crossing near the northerly edge of the Highlands. Limestone was a formation to be avoided if possible, on account of its uncertain and sometimes treacherous character, and the fact that fissures or caves often exist in it. At any of the locations of the New Hamburg group limestone would have to be traversed either in the tunnel or the shafts, and its presence was suspected, though not proved, on the southerly lines of the Highland group. At the Storm King crossing, however, the rock on both shores of the river was of granitic gneiss, which was believed to underlie the entire channel of the river.

After careful consideration of all the routes the one known as the Storm King location was adopted in the summer of 1906, the excellent character of the rock there being one of the deciding factors. The location, as determined then, affected only the plan of the crossing. The profile, or depth of the tunnel, was not fixed until late in 1910 when the various boring operations had determined the low point in the rock profile with reasonable accuracy. The aqueduct crossing is at the northern limit of the Highlands, one of the most picturesque points on the river. Storm King mountain lies on the west and Breakneck mountain on the east, both rising sharply from the river's edge and reaching elevations about 1,200 ft. above the water. The West Shore Railroad tracks follow the west shore, and the New York Central tracks, the east

shore, the latter passing through Breakneck Point in a tunnel a few hundred feet long.

The channel is 2,800 ft. wide, and the water reaches a maximum depth, about one-third way from the west shore, of 85 ft. The Hudson is a tidal stream, the normal range of the tides being about 3 ft. The mean level ranges from 0.75 to 2.25 ft. above mean sea level at Sandy Hook, depending upon the amount of freshwater coming from the north. The water is fresh in the spring, but becomes brackish later in the season as the supply of fresh water diminishes, particularly at flood tide.

The crossing as finally located is indicated in profile on Fig. 2. The long Moodna tunnel, which adjoins the Hudson tunnel on the west, and the short Breakneck tunnel, which adjoins it on the east, are also indicated. It will be seen that the river crossing is part of one long inverted siphon, or pressure tunnel, 5.5 miles long, extending from the point where the aqueduct leaves the hydraulic gradient, nearly 5 miles northwest of the river, to the uptake shaft at Breakneck mountain, about 800 ft. east of the river. The hydraulic grade at the downtake shaft is at elevation +433.75, the shaft being 594 feet deep. In the five miles to the Hudson river the tunnel falls to elevation —228.67, at which elevation it meets the downtake river shaft, which drops to elevation —1111. The river tunnel drops 3 feet more to the east shaft, or to elevation —1114, the lowest elevation reached by the Catskill aqueduct construction excepting the sump at the same shaft, which is about 42 feet deeper. The water will rise in this shaft to elevation —192, and flow through Breakneck tunnel and the uptake shaft, reaching the hydraulic gradient at elevation —410.22. The total fall is, therefore, 23.53 feet in the 5.5 miles length of the siphon. The shaft on the west shore is a construction shaft from the surface down to the intersection with the Moodna tunnel, and that portion is to be closed. The shaft on the east shore is a waterway shaft up to the land tunnel, and in addition is to be a pump shaft; differing from the typical pressure tunnel pump shaft in that it connects directly with the tunnel. The top to be capped with a heavy steel dome which can be removed whenever it may become necessary in the future to empty the tunnel.

There are six construction shafts for the Moodna tunnel, and the one nearest to the river is lined as an access shaft. This contains a circular opening, 8 ft. diameter, capped at the top, large enough for the operation of a shaft bucket.

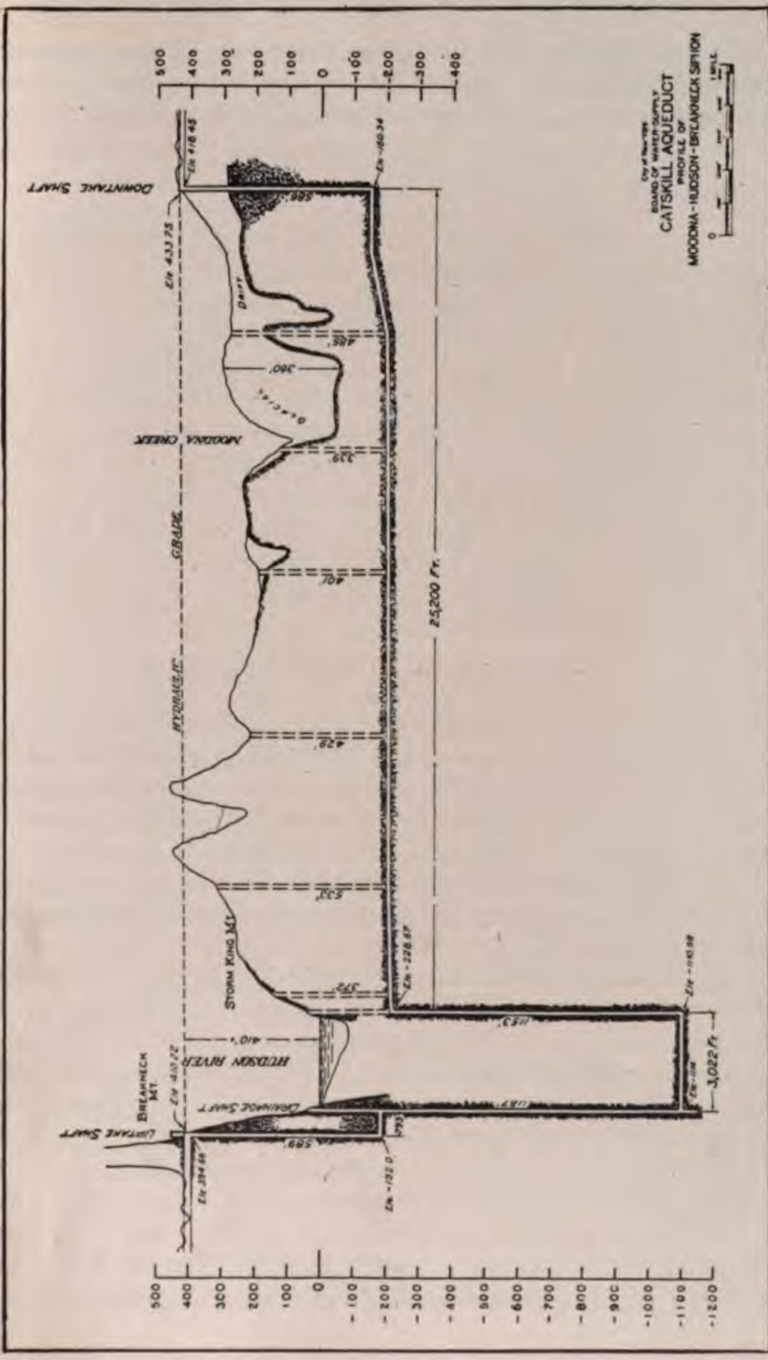


FIG. 2.—Profile of Moodna Hudson Breakneck Pressure Tunnel, Catskill Aqueduct.

With the location of the crossing decided on, it was necessary to explore the bed rock gorge of the river so that its depth and the rock characteristics could be determined, and the elevation of the tunnel fixed.

Wash Borings

Before the definite line was established, however, investigations of the sub-surface conditions had been started on the portion of the river under consideration for the crossing. The channel was explored on 14 cross-sections by the wash boring process. It was not expected that borings of this type would yield positive information as to location of bed rock, but they could be quickly made, and gave some negative information of value. All wash borings were made from the deck of a small scow equipped with derrick, hand winch and hand pump. It is interesting to note that on the Storm King line a set of wash borings bottomed at a depth of about 160 feet, whereas a diamond drill hole put down in the middle of the channel at a later date reached a depth of 768 feet without proving the position of rock.

Vertical Diamond Drill Borings.

Early in the work some diamond drill holes were put down on the shores of the river to ascertain whether any change existed in the rock structure at a depth of 500 feet or so below the surface. In February, 1906, a contract was entered into for making diamond drill borings in the channel and along the shores of the river.

Under this contract diamond drill borings were made on several cross-sections of the river, including the most northerly line indicated on the map, called the Pegg's Point line.

Three diamond drill borings were started at Little Stony Point, several miles south of Storm King. Here the river channel is very deep, reaching at one point a maximum of 130 feet. One hole was lost through the action of the elements, one by accident, and work on the third was stopped because it was deemed advisable to concentrate at the Storm King line.

Twelve holes were started on the latter line. Only three of them succeeded in reaching and penetrating ledge rock. Two were lost through action of the elements, two by collisions of tows navigating the river, and five were abandoned for one reason or another before they reached rock. The information given by these

borings, however, was valuable, as they indicated the slope of the rock for about 800 feet from either shore. There is a gap of 1,200 feet or more in the middle of the river in which rock was never proved by these vertical borings.

The difficulty of making the borings was very great in this navigable, tidal stream, having a channel 85 feet in depth, and with tidal currents running at times several miles an hour. The work necessarily had to be done from floating platforms which were affected by the currents and by storms. The wind in this notch between the mountains reached high velocities at times, and on several occasions dragged the scows from their moorings, damaging the casings of the holes so that they had to be abandoned. Another danger difficult to guard against was from the long tows of canal boats operating in the channel. Two holes were lost by these tows colliding with the casings. In one the collision damaged the casing without entirely destroying it. After a month or so of hard work the hole was recovered, and boring had hardly been resumed when another tow collided with it, completing its destruction. In the other case a boring was destroyed on which the contractor had worked one day over a year. In several other cases the loss of a boring from one of the causes mentioned represented the loss of a season's work.

The last boring made under this contract was put down in the middle of the channel, work starting in the spring of 1909. In the following December, when work had to be stopped on account of ice forming in the channel, it had reached a depth of 708 feet. Work was resumed the following spring, and continued until it was necessary to stop for the same cause in December, 1910, when the hole had reached a total depth of 768 feet without proving the position of rock. It was not considered advisable to continue work in it the following year.

For those who may not be familiar with the characteristics of the Hudson river, it should be stated that ice generally ties up navigation from the first of December to the following April. During this time, of course, no scows can be maintained in the river channel. Sometimes the ice is strong enough to drive a team on, but it is apt to break up suddenly. Generally it is floating up and down with the tides, and would carry away any scow or casing which might be anchored in the channel. While work was suspended on the borings during the winter the casings had to be

disconnected at some depth below the navigation depth, and again connected up, sometimes with the help of divers, in the following spring.

Those who wish to read a very interesting description of the methods employed in making these river borings are referred to a paper prepared for the Municipal Engineers of the City of New York by Messrs. Samuel D. Dodge and William B. Hoke, Assistant

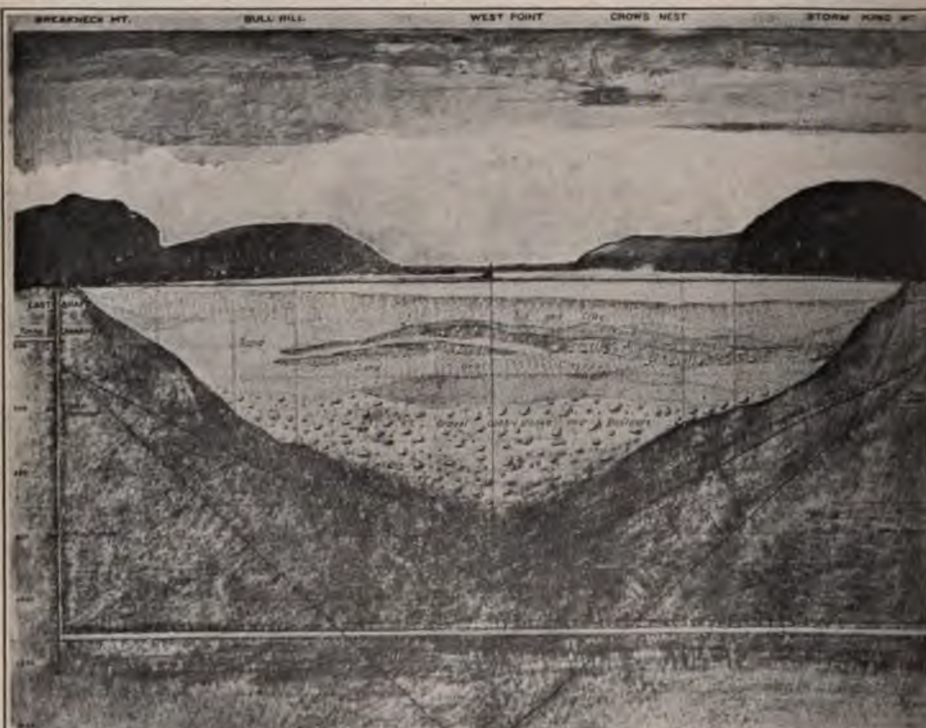


FIG. 3.

Crossing Section and Panoramic View of Hudson River Crossing, Catskill Aqueduct

Engineers on the work, entitled "Studies and Explorations of the Hudson River Crossing of the Catskill Aqueduct," and published in the 1910 Proceedings of that Society.

Fig. 3 indicates cross section at crossing, the shafts, borings and materials encountered.

Inclined Borings

As a part of the exploration for determining the depth of the tunnel it was decided to bore inclined diamond drill holes in the rock underlying the river from each shore to the middle, so as to develop the characteristics of the rock, and particularly to find out whether it contained any large seams or zones of disintegrated rock. It was realized that the vertical borings could not be relied on for this information, even if they succeeded in reaching rock in every case.

When the contract for river borings was let early in 1906 it contained a provision for boring several inclined holes under the river, starting on the river shores. The vertical borings made later in the channel at Storm King showed such a steep rock slope that any borings so started would have to be drilled at very steep inclinations, thereby causing them to pass under the river at prohibitive depths.

It was then decided that they should be made from chambers excavated in the sides of exploration shafts, this course permitting them to be drilled at flatter angles. An agreement was made with a contracting firm early in 1907 for sinking two exploration shafts, one on each side of the river, to a depth of 650 feet below tide. While these shafts were to be sunk primarily for exploration purposes, they were made the full size of a waterway shaft for possible use as a part of the aqueduct. At a depth of approximately 550 feet below tide the drill chambers were to be excavated. This agreement included a provision for drilling two or more inclined borings from these chambers.

In December, 1907, when the shafts had been sunk approximately to elevation —250, the contractor stopped work. The complications which followed delayed the resumption of sinking for over a year. This delay, together with the lack of success in determining the profile of the rock gorge by means of vertical borings in the river, made it imperative to get the information from the inclined borings as early as possible in order to fix the elevation of the tunnel. It was, therefore, decided to excavate the drill chambers at the bottoms of the shafts as they then were; that is, approximately, 250 feet below tide.

Accordingly, the first work done in the shafts in the spring of 1909 was to excavate these two drill chambers. They were on the river sides of the shafts, and were excavated on inclines of ap-

proximately 45°; that is, in the general direction that the inclined borings were to take, and were made large enough for the installation and operation of the drilling machinery.

While the chambers were being excavated, bids were called for drilling an inclined boring from each chamber to the middle of the river. Of the several bids received the lowest one, that of Sprague & Henwood, of Scranton, Pa., was accepted. The work to be done was carefully specified and payment was to be made under two items as follows:

> Item No. 1. For drilling the first 900 feet of any hole, or for drilling the remainder beyond 900 feet of any hole not included in Item No. 2, the sum of $6.50 per linear foot.
>
> Item No. 2. For drilling the remainder beyond 900 feet of any hole which either terminates within the ordered zone, or passes in solid rock above the ordered zone a hole from the opposite side of the river, the sum of $10 per linear foot.

The ordered zone is indicated on Fig. 4. It is defined by curves starting from the beginning of the borings in the drill chambers, the upper curves intersecting about 1,130 feet, and lower ones about 1,440 feet below the river surface. The zone was designed with reference to the profile of the rock surface in the river gorge as far as it had then been developed from the river borings.

The chamber at the East shaft was ready in May, 1909, and that in the West shaft in the following July. The two borings were started on June 1 and July 29 in the east and west chambers respectively. The east boring was finished at a depth of 1834 feet on December 15, 1909, and the west boring at a depth of 2051.6 feet on March 31, 1910, these depths being measured along the axes of the holes. The elevations of the bottoms of the holes were approximately —1482 and —1564 feet east and west respectively. Men experienced in drilling inclined borings in the iron regions of Michigan had stated that such borings generally showed a tendency to turn upward. With this in mind the contractor started his borings at an inclination somewhat greater than would have been necessary to have them terminate in the ordered zone provided they ran straight. The east hole was started at an angle of 43°, and the west hole, 38° with the horizontal.

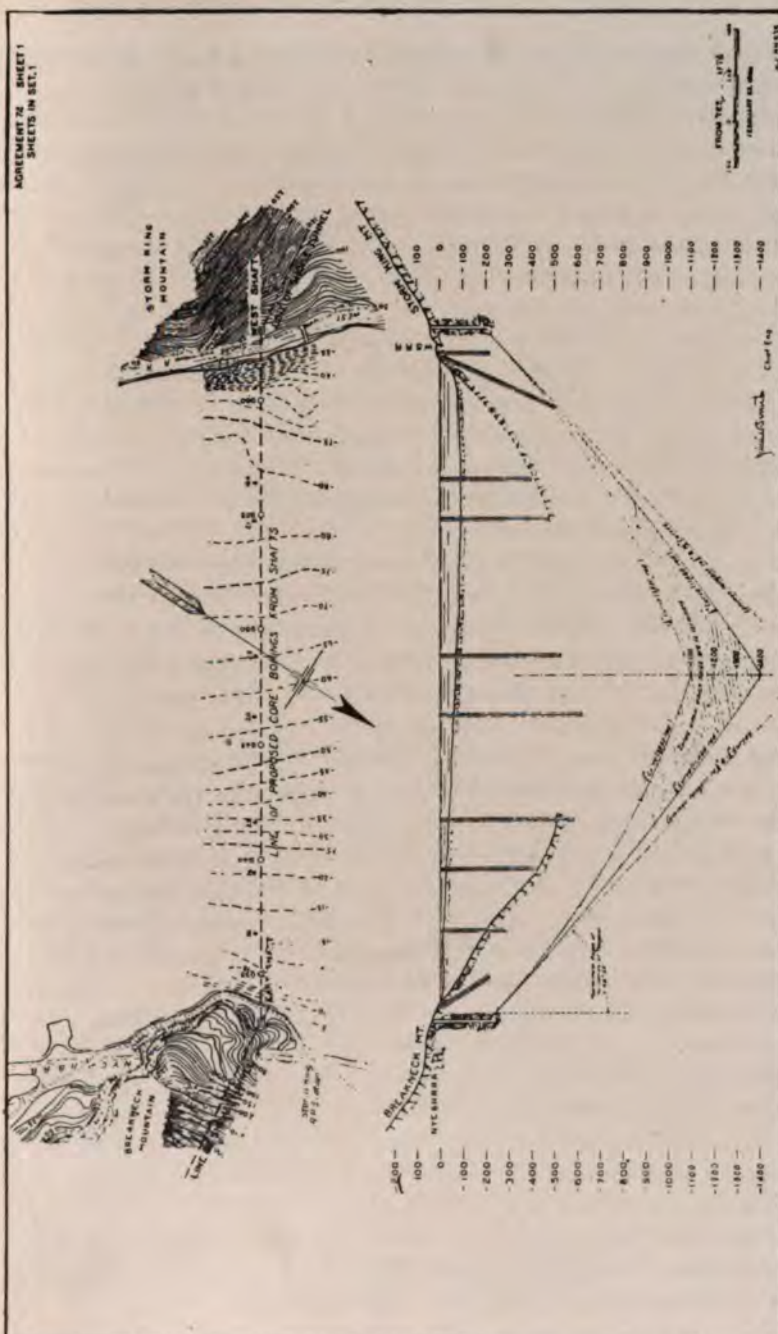


FIG. 4.—Catskill Aqueduct, Cross Section of Hudson River Crossing, showing Zones Designed for Diamond Drill Borings.

Those desiring a very complete description of this interesting work are referred to the paper of Messrs. Dodge and Hoke.

Stated briefly the holes were drilled with Sullivan Diamond B drills rated for 3,000 feet of hole. The starting diameter required was 2 1-16 inches, permitting two reductions, the last one in each hole giving a diameter slightly over 1 inch. Flows of water in the east hole gave considerable trouble, reaching a maximum of 180 gallons per minute with the hole at a depth of about 1,100 feet. This flow was practically cut off by reaming and casing. After casing, with the hole at its smallest diameter, the flow did not exceed 70 G. P. M. At a depth of 1,834 feet the bit in the east hole burned fast, and all efforts to recover it proved unsuccessful. Very little trouble was experienced with the west hole, practically no water being encountered. The depth of this hole, 2051.6 feet, is believed to be the maximum for a hole of this type in the eastern part of our country.

The successful completion of these holes showed that sound rock of the same general character as the outcrops on the shores extended under the river, and proved the practicability of driving the tunnel beneath the river. They crossed at such a great depth, however, that it was thought desirable to drill another pair of holes at a flatter angle. Accordingly a new agreement was prepared and bids were requested. Sprague & Henwood were again the low bidders, and the work was awarded to them. The two holes were drilled from the same chambers at inclinations of 22° 53′ and 23° 40′ in the east and west chambers respectively. The east hole was started April 5, 1910, and finished on August 4, at a depth of 1561.4 feet. The west hole was drilled between April 20 and August 25, 1910, to a depth of 1652.1 feet. They crossed under the river approximately at elevation —955.

Notwithstanding that in places these holes must have been but slightly below the rock surface, they continued to be in excellent rock to the end. It is a surprising fact that the east hole, drilled so much nearer the bottom of the river, was troubled with much less water than the first hole drilled at a greater depth from the same chamber. The completion of this last pair of holes furnished the information necessary to fix the grade of the tunnel. In connection with the first holes, they showed that there was no need to fear the existence of any extensive faulting, or disintegration of the rock to be traversed by the tunnel.

Following the rule that there was to be a minimum solid rock cover of 150 feet over the tunnel, the intrados of the concrete tunnel arch at the foot of the East shaft was fixed at elevation —1100, the corresponding elevation at the foot of the West shaft being —1097. As before stated, the upper pair of inclined borings crossed at elevation —955, while the vertical boring in the middle of the river bottomed about elevation —768 without proving rock. The rock surface is, therefore, between these elevations, and it is reasonable to assume that the minimum rock cover over the tunnel considerably exceeds 150 feet. Those interested in the method of determining the dip of the inclined borings are referred to the paper by Messrs. Dodge and Hoke for a complete description. Briefly the dips were determined at intervals ranging up to 100 feet by etching a horizontal line on a glass vial by the use of a weak solution of hydrofluoric acid. Generally consistent results were obtained by this method, but great care was necessary in the entire operation. Another, and generally unsuccessful, method depended in principle on the forcing of mercury (by the pressure of water in the hole) from a flat steel tube into a small cup, and ascertaining the depth by a comparison with results obtained under known pressures.

Exploration Shafts

Reference has been made to the two shafts on the shores of the river from chambers in which the inclined borings were made. These shafts were a part of the original scheme of exploration, but were designed for use as waterway shafts if the crossing was finally located there. These shafts are situated short distances back from the shore line, the horizontal distance between centers being 3022.3 feet.

Under the agreement made with the contractor in the early part of 1907, the shafts were sunk to approximately elevation —250, work being discontinued in December of that year. After considerable delay the Board decided to continue sinking the shafts with its own forces. When this decision was reached further information from the vertical borings in the river indicated a greater depth of gorge than was anticipated when the shafts were started. It was, therefore, thought best to install a plant sufficient not only to sink the shafts to a depth of at least 1,200 feet below tide, but also to drive the tunnel under the river and to line it and the

shafts with concrete. This required that the plant left by the contractor be overhauled and added to. Timber headframes were substituted for the derricks over the shafts, new hoisting engines of a heavier type were installed, and a new compressor plant was established for the west side, the plant used by the contractor for both sides being concentrated for use at the East shaft.

When these preparations were completed it was necessary to unwater the shafts, which were practically full. This was done by bailing supplemented by pumping. It was not until March 3, 1909, that the excavation work was again started in the East shaft, and on June 2 of the same year in the West shaft, the first work being the excavation of the diamond drill chambers, before noted. Before the diamond drilling was started the shafts were sunk an additional depth of 50 feet or more so as not to interfere with the drilling. As the shafts were sunk pump chambers were excavated in the sides approximately at elevations —400 and —800, the idea being to pump from the contingent 1200-foot level in 3 lifts. The chambers were made large enough for the installation of 3 Jeanesville, two-cylinder, 16x7x18, plunger pumps, rated for 400 gallons per minute against a 500-ft. head. The amount of water to be handled was, of course, problematical, but the above installation was intended to be good for at least 800 G. P. M. with one pump in reserve.

It is only necessary to mention a few of the features of the shaft sinking. The timbering consisted of 8x8 yellow pine sets, placed 5½ feet on centers, and lagged with 2-inch plank. A clear way of 9 feet 8 inches x 9 feet 10 inches was left. The timbering was done in sections of 50 feet to 100 feet, depending on the character of the rock, excavating being suspended while the timbering was in progress. The first step in timbering was to place in niches cut in the rock four 10x12 oak bearing timbers, from which the sets were built up until the gap was closed at the next set of bearing timbers above. For about 5 feet above the bearing timbers the space behind the lagging was filled with cord wood. At wet places in the shafts a concrete ring with a small sump was built at the top of the packing, and a small pump installed, which lifted the water up to the station pumps in the chamber above. When the next chamber below was ready the pump in the ring was removed and the water piped down to the chamber.

The leakage into the shafts was remarkably small considering

their proximity to the river. Only 30 G. P. M. was pumped from the 1153 feet of the West shaft. In the East shaft an inflow of about 120 G. P. M. was encountered in the vicinity of elevation —400, most of it in the pump chamber. This delayed progress materially until the water was confined to the sump in the chamber. The difficulty was increased by the fact that at the same time the first inclined boring from this shaft was adding about 180 gallons to the amount to be pumped when the hole was open; that is while the rods were withdrawn. At times, 350 gallons per minute were being pumped to the surface. The closing of the drill hole when finished reduced the inflow so that when the bottom of the shaft was reached about 140 G. P. M. were being handled, or less than the maximum amount delivered through the small drill hole. Ventilation was provided in the East shaft through a sheathed "smokejack" into which a pump exhaust was led. In the West shaft a similar function was performed by an exhaust fan and spiral pipe.

Generally the rock encountered in the shafts (classified by geologists as granitic gneiss with diorite veins) was firm and hard, but at elevation —450 in the West shaft a peculiar behavior was first noted. At this elevation "popping" rock was first encountered. Apparently the rock was under severe pressure, the local relief given by the shaft excavation causing small slabs to fly from the sides of the excavation with a popping noise. This behavior of the rock was naturally disconcerting to the workmen. The trouble from the popping rock increased to such an extent as the shafts deepened that it became necessary, in order to protect the men and to maintain progress, to keep the shaft support closer to the bottom than was practicable with timbers. The blasting would knock out the timbers unless they were at least 25 feet up. Furthermore, the time necessary to cut niches for bearing timbers was a large proportion of the period required for timbering a 50 to 100 foot stretch of shaft. A form of steel support, easy of erection, was therefore designed, consisting of 8-inch channel ribs spaced 4 ft. 1 inch on centers, and lagged with ⅜-inch plates curved to the radius of the rings. The plates were bolted to the outside of the channels which were bent with flanges in. The ribs were formed of 4 quadrants bolted together with fish plates and were placed by hanging from the next higher ring by long bolts with pipe separators. Every third or fourth ring was further sup-

ported by resting it on steel dowels driven into holes in the rock. It was practicable to keep this steel support within 15 to 25 feet of the shaft bottom. The conditions were so bad at times, however, in spite of all the precautions taken, that a number of miners were injured, one fatally, by the falling rock. A peculiarity of the popping was that it seemed to affect most the hardest and best rock in the workings; that is, the rock that would generally be considered best for tunneling operations.

The maximum monthly shaft sinking progress in the East shaft was 65 feet, and in the West, 69 feet, both made when the shafts were nearly their full depth. The fixing of the tunnel elevation, late in 1910, acted as a great impetus to the shaft sinking. Everyone connected with the work appeared anxious to get started on the under-river tunnel, the completion of which would set at rest all uncertainties regarding the Hudson Crossing.

River Tunnel

The first round of holes for turning the river heading was drilled in the East shaft on December 23, 1910, and in the West shaft on February 13, 1911. The headings were then driven 100 feet or so from the shaft. A pump chamber was excavated at the bottom of the West shaft, and the East shaft was sunk 40 feet or more deeper to form the large permanent sump for this pump shaft.

One cage was installed in each shaft, the timbering not permitting two cages. The cage in the East shaft was 6 feet 2 inches x 8 feet, and in the West shaft, 5 feet x 7 feet 2 inches. When these cages were installed, preparations were made to drive the heading under the river.

It was then considered that the exploration work was finished, and that the remaining work should be completed by contract. A contract, No. 90, was accordingly prepared, to include particularly the following features:

1. The completion of the tunnel excavation under the river.

2. The lining of the tunnel with concrete to a finished diameter of 14 feet.

3. The lining of the West shaft to the same diameter up to the land tunnel connection, and the sealing and partial refilling of the shaft above it.

4. The lining of the East shaft to a finished diameter of 14 feet

with reinforced concrete guides for a pump float and cage, and the furnishing and placing of a metal seal above the land connection.

5. A hydrostatic test of the shafts and tunnel, if required.

6. The construction of a drainage chamber over the east or drainage shaft.

Bids were called for this work and on June 20, 1911, the contract was awarded to the T. A. Gillespie Company, who began work on June 22. The estimated value of the contract was $1,649,000. The contract contained unusual requirements for progress, and called for a definite pumping equipment to be furnished and installed ready for operation at specified intervals. This equipment supplemented that of the City by completing the Jeanesville pump installation to nine in each shaft, and in addition required the installation of two electrically driven centrifugal pumps capable of discharging 500 G. P. M. to the top of each shaft.

While the contract was being prepared and advertised, and until the contractor took hold on June 22, the Board continued work with its own forces, driving the headings from the East and West shafts. By the date mentioned the east heading had advanced a distance of 268 feet, and the west heading, 218 feet, the benches being short distances behind.

When the east heading reached the distance named, on April 21, 1911, the blasting of the cut for a new round brought in a flow of water amounting to 250 G. P. M. It should be noted that the holes drilled for this cut encountered no water of moment, but the blasting apparently broke back to a heavily waterbearing seam, a few inches beyond the bottom of the holes. At this time the large station pumps had not been installed at the bottom of the shaft on account of possible injury by blasting. Water was being handled by smaller pumps used during the shaft sinking. The sudden inflow of water overtaxed these pumps and others had to be hurriedly installed. At one time the tunnel was filled to the roof, submerging some of the pumps, but the water was finally gotten under control. The tunnel was emptied on May 5, and the large station pumps then placed, since which time no trouble was experienced in handling water.

As it was not known how large a flow might be developed if the cut in the heading was enlarged, it was decided to stop excavating until adequate preparations were made to meet the situation. In

order to avoid pumping the water from the bottom during these preparations a 4-inch pipe was inserted in the cut, carefully braced in position and bedded in concrete, and then extended back to the shaft and 300 feet up the latter to the pump chamber at elevation —800. A valve in the pipe was kept open so that there was no head against the concrete while it was setting. When the concrete had set the valve was closed and the water rose under its own head to the chamber, 300 feet above. This pipe was kept in service for several months until preparations for advancing the heading were completed.

As a matter of additional precaution a concrete bulkhead was built in the tunnel by the contractor as close to the heading as was practicable. This bulkhead was 14 feet thick in the middle, increasing to 18 feet at its contact with the rock. Through it was an opening large enough to pass the muck cars, and closed by a cast-steel door, 3 inches thick, opening against the possible flow of water. It was so arranged that it could be closed quickly if necessity demanded. The pipes for air mains, pump discharge, electrical connections, etc., were built into the bulkhead.

While the bulkhead was being built and the new pumps installed, the contractor took advantage of the delay to have a diamond drill hole bored into the face of the heading parallel with the axis of the tunnel to explore the ground ahead for waterbearing seams. Although this hole was driven a distance of about 500 feet, a flow of only 32 G. P. M. was encountered, about half of it coming from within 10 feet of the face of the heading. Additional air drill holes were put into the face of the heading from 10 to 12 feet deep. Some of them encountered water and others in very close proximity did not. For example, a hole drilled 12 feet deep at an angle of 45° with the tunnel axis yielded no water, while another started close by the collar of the first yielded about 400 G. P.M. at one-half the depth. In each hole a pipe was driven for use in grouting, and provided with a valve at its outer end. When all this had been done a concrete bulkhead, 4 or 5 feet thick, heavily reinforced with pieces of steel doweled into the rock, was built against the face of the heading, allowing the grout pipes to project through. After the concrete was set an attempt was made to cut off the flow of water by grouting. This grouting was accomplished by means of a Cameron pump with large air and small water end so arranged as to pump water through a Cannif grout

tank to one of the above mentioned pipes, or bypass it around. During the grouting it was necessary to run the pump continuously to avoid the washing out of the grout by back pressure. The operation consisted of charging the tank with a batch of grout (about 2 cubic feet) then forcing same into the hole, an operation requiring 15 to 20 minutes, then opening the bypass valves while the tank was being re-charged, always continuing the pumping. The cylinder ratios of the pump were about 8 to 1, and the operating air pressure somewhat over 100 pounds per square inch. It was, therefore, possible to accumulate pressures exceeding 900 pounds and in some instances the gauge recorded 1,000 pounds. Before the grouting was done a test was made of the water pressure behind the bulkhead. The maximum pressure recorded was about 455 pounds, or practically the equivalent of the full head of the river. Of the 180 bags of cement forced in probably one-third was lost by leakage, leaving 120 bags, or something over 4 cubic yards of cement, effective for plugging the seam. After the grout had set for a few days the concrete bulkhead, and the rock to and beyond the seam which had given so much trouble, were blasted out. The grouting was found to have been very successful, and in place of the flow of at least 400 gallons which had been encountered in the drill holes, the leakage amounted to only a slight drip from one part of the roof. About 25 gallons per minute were encountered in the bottom when the bench was excavated. In the writer's opinion the water method of grouting seamy or broken rock is to be preferred to the air method in most cases, and where great pressures are to be overcome, it must be used, as air compressors cannot be obtained for working at over 400 pounds pressure. Neat cement grout must generally be used in high pressure pump work unless very fine sand can be obtained. In grouting operations of justifiable magnitude the tanks could be arranged as a battery, which, with suitable piping and valve control, would permit the almost continuous pumping of grout.

It is of interest to note that the water encountered in the inclined drill holes, the tunnel and low levels in the shafts, analyzed very differently from river samples obtained at the same time. The following table indicates comparative analyses of river and tunnel water sampled August 5, 1911, tide in the river being at end of flood:

	Tunnel Water	*River Water*
Total solids	6721	615
Sulphuric anhydride	303	41
Lime	971	35
Magnesia	183	36
Chlorine	3210	258

All in parts per million.

The difference in calcium and total solids is notable. The chlorine content of river water varies greatly with the tide and amount of fresh water flow. The analysis of tunnel water did not change materially in the three years it was under observation. The theory has been advanced that the tunnel water comes from the river, its altered chemical composition resulting from passing through a stratum of gypsum-bearing rock.

Only one other waterbearing seam was encountered in the east heading, and the inflow of about 100 G. P. M. was easily handled by the pumps.

The electrically driven centrifugal pumps, namely 2 Worthington, 8 stage pumps with 10-inch discharge to the top of shaft, were operated intermittently to remove the water. Current for these pumps was generated by a Curtis steam turbine generator near the shaft top, a cable laid in the bed of the river supplying current to the West shaft, transformers giving the desired voltage of 450. Although 2 electrically driven centrifugal pumps were installed at foot of the west shaft as a precautionary measure, they were not used, there hardly being enough water to properly test them.

The 2,090 ft. tunnel driven from the west shaft was almost perfectly dry, the total inflow amounting to less than 10 G. P. M. A pilot hole was drilled in the west heading about 5 feet in advance of the expected heading round to give information of possible waterbearing seams. A similar precaution was taken in the east heading after the excavation reached the end of the horizontal diamond drill hole above referred to. These pilot holes were drilled with the ordinary air drill.

The driving of the remainder of the tunnel was continued until the headings met on January 30, 1912, 915 feet from the east, and 2,090 feet from the west shaft. The meeting was celebrated wit' ia' monies, the Mayor of the city attending and fir error in alignment at the point of meeting

was 0.395 feet, and the difference in elevation 0.023 ft. Line was dropped down each shaft by 2 piano wires suspending 40 lb. weights immersed in water at the bottom to reduce swing. The length of base in the east shaft was 8.67 ft. and in the west, 9.5 ft. Transits were set up in the tunnel a short distance from the wires and the line, corrected for the swing of the wires, established on scales 169 ft. apart in the east heading, and 181 ft. in the west. From these bases line was produced and established on roof scales set at intervals of about 400 ft., roof plugs about 50 ft. apart being used for alignment between scales. In establishing line from the piano wires 4 observations were made on each side of the river by 2 parties of 3 observers, each of whom made 4 settings of the transit and 4 sets of direct and reverse readings on each scale.

The popping rock gave some trouble in the tunnel, but not to the same extent it had in the shafts. It was necessary in some places to erect a light steel roof support of the same general design as that described for the shafts. The wall plates consisted of a heavy angle iron, the ribs of two angle irons bolted together, and the lagging of one-quarter inch curved plates.

Ten feet per day was the normal advance for the heading from the west shaft, and 7 feet, from the east shaft, the top heading and bench method being followed. Two short rounds were fired per day in the west, and one long round, in the east heading. Four drills on columns were used in the heading, and two on tripods for the bench. An average progress of 269 feet per month was made from the west shaft, with a maximum of 300 feet and a minimum of 238 feet. No attempt was made to beat records in tunnel driving, the depth of shaft and single cage operating against the success of such an attempt. The tunnel excavation section differed somewhat from that of previously excavated pressure tunnels in that it called for a flat bottom about 10 feet wide, which gave more room for tracks and turnouts, and permitted more complete mucking. In the circular excavation section muck was necessarily left on the bottom to provide necessary width for tracks. Its subsequent removal in advance of concreting often delayed that operation.

Concrete Lining of Tunnel

The plans provided that the east shaft be lined as a drainage shaft, necessitating somewhat complicated construction in the 42-

ft. sump, the placing of two pairs of concrete guides from bottom to top, and special metal construction at the top to withstand heavy bursting and lifting pressures. The west shaft was to be lined as an ordinary waterway shaft, and presented no unusual difficulties. Accordingly, it was planned by the contractor to line practically the entire tunnel excepting the invert from the west shaft. The invert, about 5 feet in width, was placed for the entire tunnel, three 45-ft. sets of Blaw tunnel forms being set up on the completed invert, dividing the tunnel into thirds. The so-called "trailing" form method was used in concreting. A length or two of sidewall (invert to spring line) was first poured at each set of forms, thereby permitting the erection of the arch form. The subsequent day's work required the arch form to be filled to the key, and during the keying operation, which could use only a few men, the next sidewall form was concreted. The use of three sets of forms permitted one to be filled each day and another moved. Those interested in complete descriptions of tunnel lining methods, which have been highly developed on the Catskill work, are referred to Mr. White's book, and to the bibliography in the Appendix thereof. The following description of the concreting plant used at the Hudson river crossing, and the method of concreting is quoted from Mr. White's book.

"A very convenient plant was installed at the top of the west shaft to supply concrete for the entire tunnel. Barges of sand and broken stone were unloaded at the dock by a derrick and grab bucket which filled a small hopper feeding on to a belt which in turn discharged into a longitudinal belt over the sand and stone bins near the shaft. The belt over the bin was equipped with a tripper so that the bins could be kept uniformly filled. The concrete measuring and charging cars were filled from the bins and hauled by a small hoist up an incline to a large Smith mixer, which discharged a batch twice the usual size directly into a large twin-hopper car on the cage. This car at the bottom of the shaft automatically discharged into two cars, one each side of the shaft. The concrete cars were hauled by electric trolley dinkies to the forms, which were used in a manner very similar to that employed at the Wallkill and Rondout siphons. Although a 40-foot side wall and arch form was filled daily, it is reported that the single cage is a considerable handicap during concreting, as there was little time to take the hopper car off and use the cage for other purposes such as cleaning and mucking out tunnel, etc. A particularly rich mix, about 1-1½-3 (2 barrels

cement per yard) was used for all the concrete in order to secure water-tightness. The lining averaged at least 17 inches effective thickness."

Grouting of Tunnel

During the progress of lining, pipes for grouting were set at seams in the rock, high points in the roof and near the ends of sections of roof concrete, in order to cut off water, fill voids over the concrete arch and close openings in the arch at ends of successive days' work. The grouting was done in two operations. After the completion of the entire lining, the first, or low pressure work, was placed by air up to 100 pounds pressure, the second, the high pressure work placed by air up to 300 pounds, and by pump from 300 to 600 pounds. Neat cement grout was used in some cases, and in others equal parts of cement and sand. The grouting was generally successful except toward the east end of the tunnel where trouble was experienced with cracking the concrete lining by the application of the high grouting pressures. Through this stretch trouble was experienced during the concreting because of the seepage of water through the rock, and the quality of the concrete was apparently affected thereby. A few pipes were left ungrouted and equipped with bronze check valves to close against the internal pressure, thereby preventing loss of water outward, and to open with the external pressure, thereby relieving the tremendous pressure on the concrete lining when the tunnel is unwatered for inspection. Special tanks were built to withstand the high pressures used in the water pumping method.

Shaft Lining

The lining of the west shaft presented no difficulties, as the shaft was practically dry. Steel or timber support was removed in convenient stretches and the concrete placed behind Blaw steel forms in sections up to 20 feet in length. The removal of shaft timber necessitated the use of bucket transportation, concrete being dumped on to a platform on top of the forms and then shoveled into the forms. Pump chambers were filled with concrete as reached, and later grouted. After the final cleaning of the tunnel and removal of plant from same, the 50-ft. plug over the junction with land tunnel was concreted, this operation practically completing the west shaft.

The lining of the east shaft was a more difficult operation because of the greater amount of water and the complications resulting from the concrete guides which were built monolithic with the lining. These guides (two pairs) serve to guide the cage, float and discharge pipe in the unwatering operation, and hence must be very true as to alignment, clearances, etc. Special forms were required, the guide forms themselves being castings attached to the circular steel form. A 5-inch galvanized pipe was built into the lining in a vertical position for possible use as a discharge line in future maintenance operations. The general methods of concreting were similar to those used in the west shaft, but progress was necessarily slower because of the guides. Some grouting of the shaft lining was required where the rock was seamy and water-bearing.

Special Construction at Top of East Shaft

As stated before this shaft will be used as a pump shaft for unwatering the Moodna-Hudson tunnel. Comparatively easy access must, therefore, be provided, and at the same time the construction for withstanding the enormous bursting pressures when the aqueduct is in service must be adequate and watertight. Fig. 5 shows the special construction in detail.

The total pressure under the cover during service will be about 1,975 tons, or 12½ tons per square foot. To aid in securing watertightness an interlining of riveted steel, ⅜″ thick, 14′ 10″ diameter, is provided in the concrete lining, starting at elevation —175 and continuing up the shaft to about elevation +10, where it is attached to the cast-steel curb on which the heavy steel cover rests. This interlining was provided with inside flanges at circular joints and was lowered into the shaft in full sections, generally about 15 ft. long, the circular joints being bolt connected and calked. Previous to placing any of the permanent work above elevation —175, all timber was removed between that level and the top of the shaft. The concrete lining was carried up outside and inside the interlining as the latter was built up. At about elevation —36 comes the so-called anchor ring, a steel casting attached to the interlining above and below, and intended primarily to serve as the lower anchorage for the special steel bolts which carry the lifting pressure against the cover. To insure the anchor ring being exactly horizontal and at the correct elevation,

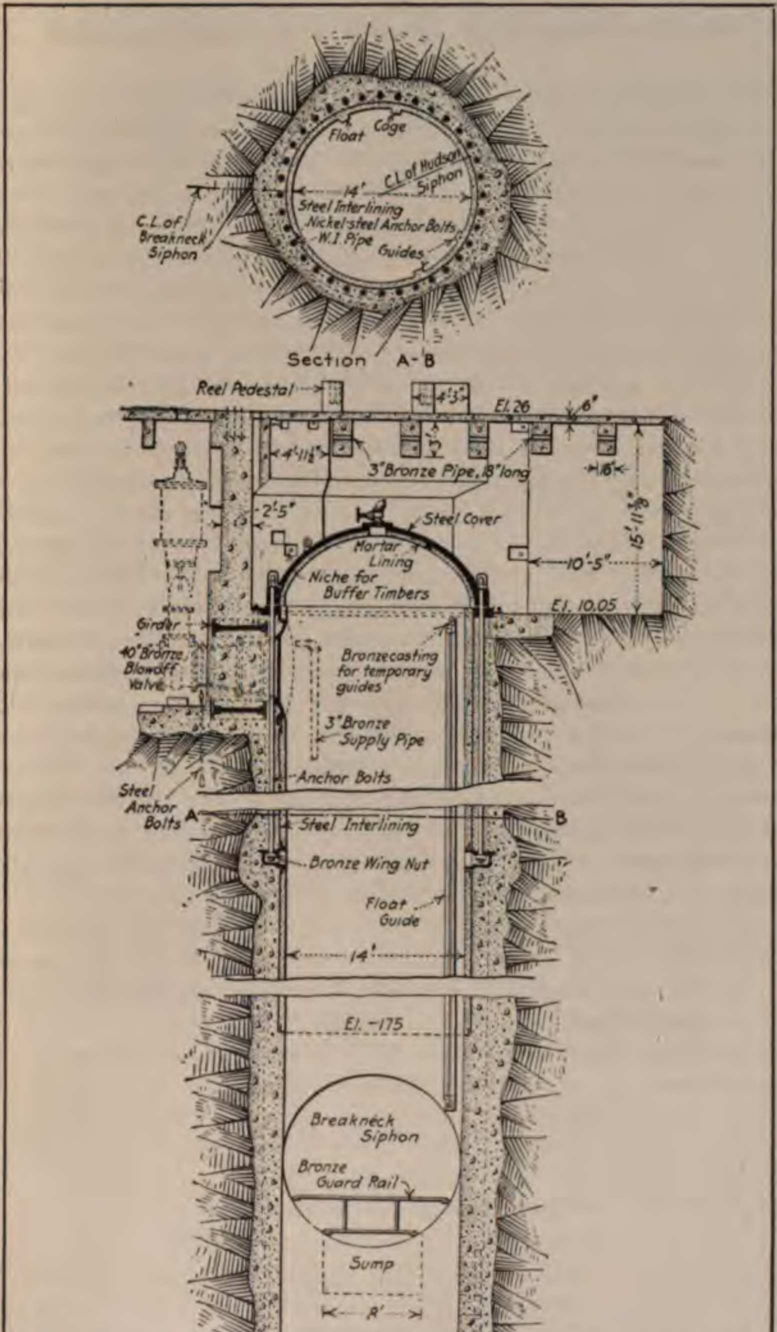


Fig. 5.

Top of the East Shaft, Hudson River Siphon, Catskill Water Supply.

the connection between it and the steel interlining was drilled after assembly in the shaft. The cast-steel cap or cover is a single casting, weighing 92,000 pounds, and having the following dimensions: maximum diameter at base, 16 ft. 11 in.; inside diameter corresponding with waterway, 14 ft.; rise on inside, 6 ft.; thickness varying from 3 inches at crown to 8 inches at base.

The cover rests on a cast-steel curb, and is held against this curb by 36–4½-inch diameter bolts of nickel-chrome steel, which extend down into the anchor ring about 50 ft. below. A special gasket is provided at the junction of the cover and curb. All bearing surfaces on cover and curb are machined, and nut seats spot faced. Each bolt is cased in a steel sleeve, 5 inches in diameter, made up in five sections; the top and bottom sections of cast-steel with projecting concentric ribs to insure a better bearing surface against the concrete, and with special machined ends to insure proper bearing against curb and anchor ring. The intermediate sections are of extra heavy steel pipe with special sleeve joints, calked with lead wool. The top and second sections are connected by a special screw coupling which permits final exact adjustment against the curb. The space around the 4½-inch bolts in the sleeves will be filled with oil to prevent corrosion. In addition the bolts are to be capped with bronze caps to protect their extremities from corrosion, and the bolt hole through the cover base is bronze lined for the same reason. The inside of the cover is protected by a 3-inch coat of mortar plastered over reinforcing metal attached to screw eyes located in tapped holes.

The bolt specifications called for

Tensile strength	100,000 lbs. per square inch
Elastic limit	80,000 " " " "
Elongation	20%
Reduction of area	45%

Tests of standard 2″x½″ bars from the ends of bolts indicated results considerably in excess of the above, and in addition one full sized bolt was broken in the testing machine at the Phoenix Iron Works, Phoenixville, Pa. Owing to limitations of the testing machine as to length of specimen tested, it was necessary to cut the bolt to a length of 20 ft. It failed under a total load of 1,716,000 lbs., or 107,000 lbs. per square inch. Each bolt weighs

about 1½ tons, and in service will carry a water pressure load of 55 tons, or about 7,000 lbs. per square inch. Variations in temperature will increase load to over 20,000 lbs. per square inch.

In assembling the work above the anchor ring, the first section of ⅜-inch interlining, 9 ft. long, was lowered into the shaft and field connected to the ring. It was originally contemplated to set the sleeves and hold them accurately in alignment during the placing of the concrete, afterward lowering the bolts into them. Owing to the small clearances and minor irregularities in the castings the sleeves and bolts were assembled together, after which three 9-foot lengths of ⅜″ interlining were lowered and the curb set and everything brought to line and held by bracing and templets. After the lower calking was finished the outer concrete lining was carried up about 9 ft. to the interlining joint, the work then proceeding in similar stretches to the top of ⅜″ interlining. The upper section of interlining is ¾″ thick. This is field connected and collar-bolted to the curb, and field riveted to the ⅜″ lining, all joints being carefully calked. The placing of inside concrete lining between the anchor ring and curb will complete work in the shaft.

The cover was cast at the plant of the Midvale Steel Company, and before shipment was subjected to a hydrostatic test pressure of 250 lbs. per square inch, for which test a special steel dead cap, 12 inches thick and 17 feet diameter, was provided. This cap weighed 114,000 lbs. without risers. The casting was shipped in a special car to Jersey City and thence lightered to the job. A very complete description of the cover and bolts, together with an account of their manufacture, the results of tests, etc., appeared in the "Engineering News" of October 9, 1913.

The final operation of closing the shaft for the hydrostatic test will consist of placing the cover and then stressing the bolts to working loads, afterward bringing the top nuts to a firm bearing. This preliminary stressing is expected to prevent any opening of joints under working conditions. For stressing the bolts a special apparatus has been designed, consisting of a lug nut to be screwed down above the top nut, and stressing link device which engages this lug nut and is operated by hydraulic jacks seated on steel standards which fit over the two adjacent bolts and rest on the steel curb. Four of these devices are provided in order that stressing may be done gradually and at diametrically opposite

bolts at the same time. The final stressing will not be attempted until the concrete under the curb has had time to age sufficiently.

After the cover is set the Moodna-Hudson tunnel will be subjected to hydrostatic test by filling with water to the elevation of aqueduct invert at Breakneck tunnel (approximately 400 ft. above the cover level).

A blowoff connection, 40 inches in diameter, is provided just under the cover for drawing down water in the terminal shafts. Under full pressure its capacity is that of the aqueduct, or 500,000,000 gallons daily, and the velocity through the nozzle under these conditions is about 100 ft. per second. The blowoff nozzle of cast-bronze is collar-bolted to the top ring of interlining, and water is controlled by two 40-inch valves hydraulically operated, the inside one of bronze and weighing complete 29,000 lbs., the other of cast-iron, and slightly heavier. A 12-inch bypass, controlled by two valves, is also provided, together with suitable piping for operating the cylinders on the 40-inch valves. The blowoff discharges into a concrete stilling chamber, where the velocity is reduced, and from the stilling chamber the water flows through a double concrete conduit into the Hudson river. A concrete chamber is built over the shaft, and over this will be built later an imposing superstructure. This superstructure, together with contemplated improvements along the adjacent river front, will remind passersby of what is popularly considered the most marvelous feature of New York's new water supply.

Operation

The most interesting detail in connection with the operation and maintenance of the Hudson tunnel will be the unwatering, which will be undertaken only when necessary for inspection or repairs. Preliminary to unwatering the tunnel the water in the terminal shafts will be drawn down through the 40-inch blowoff referred to above. The cast-steel cover will then be unbolted and moved to the chamber annex provided for its accommodation. Lifting attachments are provided on the cover, also track connection into the chamber annex to facilitate handling. The unwatering equipment will consist of a riveted steel float, 12 ft. 9 in. diameter, and 35 ft. in height, equipped with continuous angle iron guides which engaged the concrete guides in the shaft. This float will

be used for this tunnel only and will be stored in the chamber when not in use. It will be launched from a recess leading from the side of the shaft. The pumps, motors and other equipment used in unwatering operations will be transported from place to place as needed. Within the float will be placed two 4 stage centrifugal pumps, each with a capacity of 1600 G. P. M. against a head of 550 ft. They will be driven by two electric motors operating at 1800 revolutions per minute, the current for these motors being transformed to an operating voltage of 2200, and supplied to the motors through a cable arranged to feed from a reel on the chamber floor. The pump suction is taken through the bottom of the float and the discharge is through the top, successive lengths of 10-inch pipe being added as the water is pumped out and the float sinks. Steel brackets clamped to the discharge pipe engage the concrete guides in the shaft and maintain the discharge line in a vertical position. Communication between the float and the top of the shaft is furnished by a cage operating on the second pair of concrete guides. The maximum volume of pumping at the Hudson siphon will be at about elevation —230, where the volume in the five miles of Moodna tunnel (about 23 million gallons) must be removed. About half way down the shaft the pumps must be connected in series to overcome the increasing head. When the float is at the bottom of the shaft its top will be just below the invert of the tunnel, thereby giving opportunity for inspecting and cleaning the tunnel. On completion of the cleaning or repairs the float will be raised to the top by letting in water, lengths of discharge pipe being removed as the float rises. The pump equipment was tested out at Rondout Siphon where it worked very satisfactorily under a maximum head of about 500 ft. In order to demonstrate the serviceability of the pumps under Hudson tunnel conditions they were connected in series during the Rondout operations and the discharge throttled down until the gage registered 1200 to 1300 ft. head. They were satisfactorily operated for three hours under these conditions.

In conclusion, it should be stated that construction work on the Hudson tunnel is practically completed. The operation of placing the cast-steel cap will be undertaken in a few days, and it is expected the tunnel will be ready for hydrostatic test within two months. On completion of the test it is intended to unwater

the tunnel for purposes of inspection, also to test out the efficiency of the unwatering equipment under the difficult working conditions that will obtain.

The author wishes to record his indebtedness to former Department Engineer Robert Ridgway for material taken from a paper prepared by him for the Engineers' Society of Northeastern Pennsylvania, to Mr. Lazarus White for data obtained from his book on the "Catskill Water Supply," and to Mr. William B. Hoke, assistant engineer in immediate charge of the construction, for helpful suggestions in the preparation of this paper.

The work was carried out under the direction of Mr. J. Waldo Smith, chief engineer, Mr. Robert Ridgway, department engineer, Northern Aqueduct Department until January 16, 1912, and the writer as department engineer since that date, Mr. William E. Swift, division engineer, Hudson River Division to December 1, 1911, and Mr. Frank L. Clapp, acting division engineer since that date, and Mr. William B. Hoke, section engineer. All designs were prepared under the direction of Headquarters Department, Mr. Alfred D. Flinn, department engineer, this department also looking after the inspection of manufactured materials.

PAPER No. 1135

CONCRETE ROADWAYS

BY LEWIS R. FERGUSON

Read December 20, 1913

The history of our country is replete with instances where the ingenuity of our engineers has been called upon to meet difficulties due to changed conditions and new problems involved.

That necessity is the mother of invention was never more forcibly illustrated than in the development of the concrete road. Mr. Fulweiler, in an able paper presented to this club, described the origin of the macadam road, and discussed the causes which have necessitated a change in modern methods of road building. He pointed out the importance of having a surface that could not be disrupted by fast-moving, high-power automobiles. Within the last few years there has been a further development in traffic conditions, and it has caused grave concern on the part of highway engineers and those interested in road construction. It is the heavy motor truck. Practically everyone realizes the imperative necessity for improved roads. The growth of public interest in improved roads has, within the last few years, been nothing short of marvelous and will be recorded by historians as one of the most important epochs in the history of our country. In cities we recognize permanent roads as essential to our very existence. For example, imagine the condition of affairs in this town with pavements no better than our country highways. The traffic of the city would be halted, and its industrial and commercial life become stagnant and blighted. But in this day even the man in the suburbs demands that he have first-class roads. The value of his property and the comfort of life depends to a great extent, if not altogether, upon good roads, for his greatest asset is his ability to travel readily to and from the city. The farmer already understands what good roads will mean to him, and this touches all classes, for the prosperity of the whole country depends, in a large measure, upon the wealth produced from the soil. The

migrations of the past few years from country to city have become a serious menace through the depopulation of agricultural districts. The cause of this movement away from the farm is almost wholly due to lack of good roads. During certain seasons of the year the farmer and his family are practically isolated. It is even difficult for country children to attend school at certain seasons, and social intercourse becomes a task rather than a pleasure. Business is suspended and crops cannot be moved. Is it any wonder that a spirit of unrest prevails among our farmers? The farmer's bad roads represent a vast waste of his resources and opportunity. During the spring months, when prices for early farm products are highest, the roads are usually so bad that he cannot get to market. If the roads were in a good condition the entire year, there would be a more even distribution of farm products in our markets and both the producer and the consumer would be greatly benefited. The railroads have awakened to the importance of good roads. During the season of heavy transportation it is most essential that freight be delivered as uniformly as possible. In this way the number of cars required can be determined and the least delay will occur in loading. If during this time the roads become impassable, due to heavy rains or thaws, all calculations are upset. The cars stand idle for a time and then when hauling can be started again, the produce comes more rapidly than it can be handled. It is piled on the platforms to the point of congestion if it does not spoil. Both the railroad and the farmer suffer serious loss.

With the wide-spread interest in good roads and the growing knowledge of their importance, it is surprising to learn that less than 10 per cent. of all of our highways are improved. It is still more surprising to discover that there is a great hesitancy on the part of many, and an absolute antagonism on the part of others, when an extension of our present system of improved roads is suggested. It is only necessary to point to the recent defeat of the proposed bond issue in this state, and very significant is the attitude of the farmers who make the boast that they were the cause of its defeat.

Why should there be such antagonism on the part of anyone to an extension of improved road systems? The cause is largely one of cost—not first cost of construction, for people are willin[g to] spend money to build roads—but the everlasting cost of m[ain]tenance. In too many cases the cost of maintenance far exc[eeds]

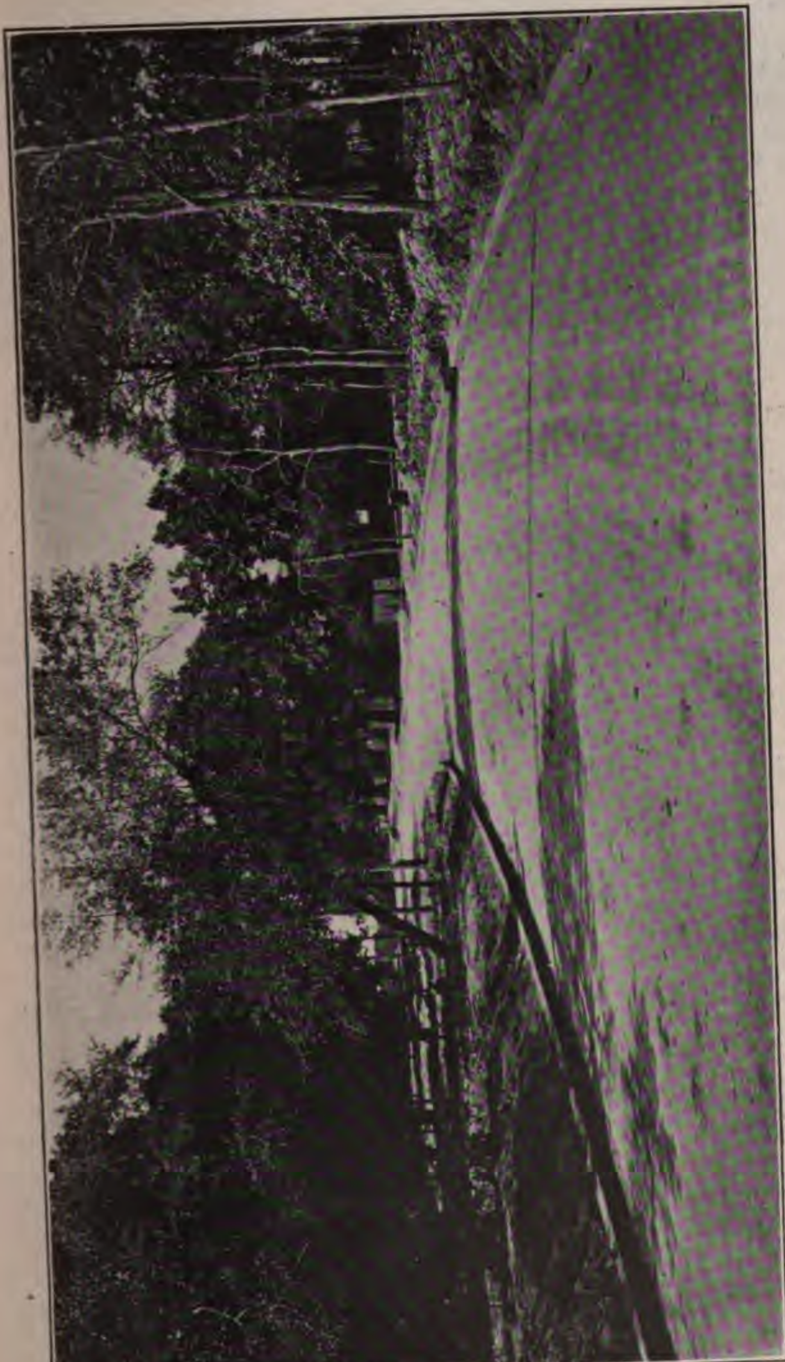


Fig. 1.—Concrete Road in Pensacola, Florida.

the interest on the bonds used to build the roads, and it is not unusual for the roads to wear out long before those bonds mature. No one enjoys paying for a dead horse. Maintenance cost brings us to the most important factor in modern highway construction.

Accurate maintenance costs for improved roads are very difficult to obtain, but an average figure can be secured from various highway reports. In Lower Merion Township, a suburb of Philadelphia, there is spent about $640 per mile per year on existing roads. This includes resurfacing of worn-out roads, but not rebuilding.

The cost of repair and maintenance in Massachusetts during 1912 was $667 per mile. In New York $1,099 per mile was spent.*

The average cost for the last five years for maintenance and repairs in Connecticut, Massachusetts, New Jersey, New York and Rhode Island was $649. During 1912 it amounted to $814.*

During 1911 the appropriation for road work in Rhode Island was $200,000, of which $80,000, or 40%, was for maintenance.

The report of the Good Roads Committee of Monroe county, New York, for 1911, gives some interesting data regarding the life of the macadam type of pavement having an oiled surface. It is claimed that this county has the largest value of farm products of any county but one in the United States, and, therefore, has paid special attention to its road construction and maintenance. Up to November 1, 1911, they had constructed 177.7 miles of improved highways, including state and county systems; approximately 50% of which is plain macadam with oiled surface, of either hot or cold application. The first roads built under state and county aid were put down in 1899, and additional roads have been built every year since except 1910. Of the total 200 miles built or under construction at the time of the report, all but 33.56 miles have been water bound macadam. All roads have since received surface treatment except 6.8 miles. The average construction cost per mile was was $8,371; the average cost of maintenance per mile per year, $471; and the average age of the state roads has been 6.1 years. The total original cost of the 200.86 miles was $1,374,469, and the total maintenance cost has been $457,683, or a total of 33 per cent. of the original cost. One road approxi-

*Bulletin No. 48. United States Department of Agriculture, Office of Public Roads. "Repair and Maintenance of Highways."

mately 4.7 miles in length was constructed in 1908 of tarvia-bound limestone at a cost of $10,125 per mile. The average maintenance cost per year for the three years of its existence has been $588 per mile, or, in other words, the maintenance cost for three years has been 17 per cent of its original cost.

According to Col. Spencer Crosby, U. S. Army, in charge of Buildings and Grounds for Washington, D. C., the cost in Washington of oiling macadam park roads with an asphaltic oil during 1911 was from 1.2 cents to 4.6 cents per square yard per application exclusive of the gravel or stone screenings which required about 1 cubic yard for every 75 to 125 square yards of surface.

FIG. 2.

Sprinkling the Road and Covering it with Earth the day after Laying. This is done in order to Cure the Concrete. The Earth Covering is kept moist for at least seven days.

Various kinds of emulsions were tried, but it was found that the effect of each application only lasted from two to three weeks, depending upon the amount of rain, etc.

Is it any wonder that a discussion of highway construction almost invariably develops the fact that the cost of maintenance is a most essential feature in economic road work? Highway engineers throughout the country recognize the fact that some form of

permanent binding material must be used if roads are to hold together under the severe conditions of traffic to which they are now exposed. This binder must be one which will not disintegrate under climatic changes. It must give a road suitable for use during the hot summer months as well as the cold winter months. The road must not become dusty in dry weather, nor must it become muddy in wet seasons. The concrete road has a binder which increases in strength with age. A binder of Portland cement is not affected by climatic changes. While it is only within comparatively recent years that concrete roads have been extensively built, there are a few examples of concrete roads that have been constructed for a sufficient length of time to furnish us with interesting data relative to maintenance cost.

The earliest concrete pavement of record was laid in Bellefontaine, Ohio, in 1893–4. There has been an expenditure for maintenance and repairs on this street of about ¼ of a cent per square yard during the first twenty years of use. The surface of this pavement was scored to imitate the joints in a brick or block pavement, the idea being that this scoring was necessary to prevent the surface from being slippery. Today this pavement is in excellent condition with the exception of a few grooves worn in the longitudinal joints.

A concrete alley was laid in the down town district of Richmond, Indiana, in 1896, and shows practically no wear at the present time.

In Wayne county, Michigan, there is now about 90 miles of concrete road. The first work in this county was done in 1909. Maintenance charges on the roads for the last year were about $26 per mile. On the score of maintenance costs concrete makes an ideal type of road for country highway purposes.

The cost of the construction of every type of road depends to a great extent upon local conditions, such as the cost of grading, the cost of labor, the condition of the sub-grade, cost of materials, and the method of construction. Taking an average of practically all the concrete roads of which we have been able to secure records, amounting to over 10,000,000 yards, constructed throughout the United States, the cost is $1.26 per square yard, or about $12,000 per mile for a 16-foot road.

State Highway Commissioner Bennett, of Connecticut, in a recent statement, said that bids on concrete roads in his state were running less than $1 per square yard, including grading.

The contract price for three miles of concrete road with bituminous top, built at Bethayres, Pa., this year, was $1.10, exclusive of grading.

Maryland has made a remarkable record in the construction of concrete roads, costs in some instances not exceeding $9,000 per mile of 16-foot road.

Any road building material which is to give satisfaction must be suitable both for horse drawn and motor traffic.

The concrete road, and I am speaking of a concrete road with a concrete wearing surface, fulfils both of these requirements.

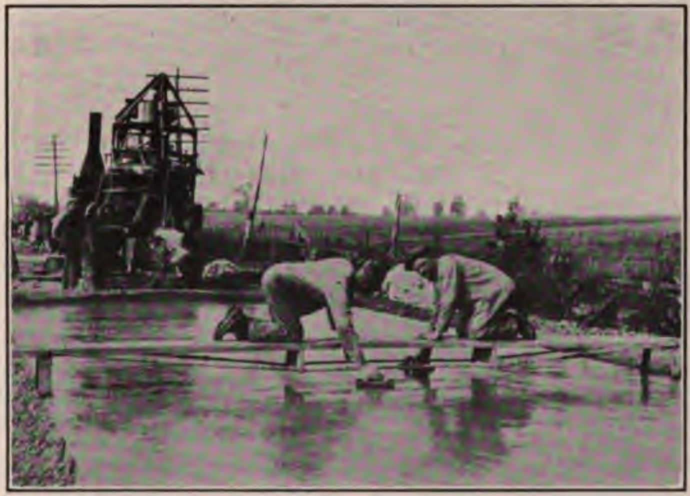


Fig. 3.
Smoothing the Rough Places by Means of Wooden Floats.

I have had occasion to inspect many miles of roads built of concrete, and with concrete wearing surfaces, and have taken particular pains to interview as many drivers as possible, in order to discover the effect on horses. I have found not a single instance where the driver of a horse stated that any injurious effect was noted. Owing to the low tractive resistance of concrete the horse is able to pull a far heavier load with much less effort in all seasons of the year than over any other type of country road. In Wayne county, Michigan, to which reference has been made, the concrete roads have been extended to practically every part of the county,

and the farmers are a unit in giving the highest endorsement to them. The only criticism to which the highway commissioners have been subjected is that they have not extended the system of concrete roads more rapidly.

During an inspection trip over a concrete road in Warren county, New Jersey, we had an interesting talk with a veterinary surgeon who had had a particularly good opportunity to observe the effect of this road on horses. He was a user of the road and gave it his unqualified approval, stating that instead of being injurious to a horse, he believed that it was actually beneficial.

A concrete road, owing to the impervious nature of the material of which it is constructed, and the rapidity with which water will run from it, is built with a crown of only ¼-inch to the foot. This permits of a sure and even foothold for the horse. Instead of the horse's hoof meeting the surface of the road at an angle, it comes down upon an almost flat surface. On a concrete road there are no loose stones and no tendency for the horse to twist knees or shoulders. Anyone who has been over a concrete road will be convinced at once that the surface is not slippery. The most injurious slipping effect of any type of road is caused by the side slip and not by the front or back slip. Here, again, the low crown of the concrete road offers an important advantage and safeguard for horses.

Trolley lines run beside many of the roads in Wayne county. A thorough canvass of the conductors, whose cars parallel these concrete roads, brought out the fact that not one had ever seen a horse fall on these roads.

Resiliency is a question greatly discussed by highway engineers, and it is often thought an essential requisite. That this is to a great extent a fallacy is seen when one considers a brick street or an asphalt street in winter time laid on a concrete base. Certainly a Belgian block surface, laid with grouted joints on a concrete foundation, possesses no resiliency, and yet, for the heaviest kind of traffic, this type of pavement has, among many teamsters, by far the greatest preference over any other type of street surface.

Another distinct advantage of the concrete road, due to the low crown, is the fact that the whole width of the road is available for traffic and there is no tendency to drive continuously in the center. The wear is, therefore, distributed over the entire surface.

For the motor-driven vehicle it is obvious that the concrete road

is an ideal highway. Its low crown and even surface, the latter of a texture sufficiently gritty in dry or wet weather to obviate any possibility of skidding, makes it safe and comfortable for either low or high speeds under any conditions. Water flows rapidly from this dense and even surface of the concrete, thus preventing the formation of ice during the freezing months.

Heavy motor trucks are becoming more and more popular. The concentrated load they bring to the surface of a road is enormous. It is becoming a common sight to see motor trucks, carrying a load as high as 10 tons, traveling over our highways at speeds

Fig. 4.
A 16-ft. wide Concrete Road, showing a 2-ft. Stone Shoulder.

of fifteen miles an hour or over. Sixty per cent. of this load is on the rear axle and is concentrated over a very small area under the rear wheels. To distribute this load to the sub-base, which, in truth, is the function of a road surface, requires a firm and strong medium. The constituents of the road must be held rigidly together. Engineers recognize the fact that in city streets, where traffic is heavy, the pavement must have a firm and absolutely unyielding foundation. Today it is just as essential for our country roads to have such a foundation. Both the heavy motor truck and the fast moving automobile exercise a tremendous

tangential shearing force on the road surface. This force has a tendency to dislodge or shove slightly out of place any particles not held firmly in position. It has been thought that the speed at which the vehicle was moving determines to a great extent the disintegrating effect. I believe, however, that the exertive horse power of the machine is, to a far greater extent, the determining factor. In any event, the surface of the road must be of such a character that it will be neither moved nor dislodged, which means that the binding material used to hold the component parts of the road in place must be strong enough to prevent even creeping of the surface. In many types of roads we find that after a comparatively short time of use the surface becomes wavy. The cause of this waviness is at present being investigated by many highway engineers.

Sometimes unusual conditions arise which particularly favor the use of concrete. In Selinsgrove, Pa., a section of a road is subjected to flooding from an adjacent stream and each year the road washed away. In 1911 a concrete road was constructed and is at present in excellent condition.

In Whitehall, Baltimore county, Md., a similar condition existed and the difficulty was also overcome by building a road of concrete.

At LaSalle, Illinois, the Illinois river rises, during flood conditions, to a height of 15 feet and submerges the surrounding country. The only permanent road they were able to build was of concrete as this material is in no way injured by water.

In building a concrete road the sub-base is rolled in the usual manner with a medium weight roller. A foundation dry and firm, with a covering that will not allow water to pass through it, is the chief characteristic of a road of the best type. If the sub-soil is of a character to retain water, it is very important that such a system of underdrainage be installed as will carry the underground water from beneath the road.

With the water taken care of, the sub-base should be compacted until there is no creeping in front of the roller. The evenness of the sub-grade is of great importance. There must be no humps or depressions. The concrete must have every opportunity for easy movement in order to adjust itself to temperature and moisture changes. When a mixer is used it should be run on planks in order that the sub-grade may be kept in good condition.

For roads up to 16-feet wide the base should be flat and all the

crown thrown in the surface. At all times the sub-base must be thoroughly wet before any concrete is placed upon it. Particular attention must be paid to this during the dry summer months. If this is not done water will be absorbed by the base and there will not be the required quantity in the concrete to allow of uniform set and strength. Should the work be a country road, forms are set in place and the space between them filled with concrete. If a city street, the curbs or gutters act as side forms.

The thickness of the concrete at the side of the road determines the height of the forms. This is usually not less than 5 inches. A crown of one one-hundredth the width of the road, or a slope of ¼-inch to the foot, is all that is needed. By making the sub-base of a 16-foot road flat the thickness of the road would then be 5 inches at the sides and 7 inches at the crown. If the road or street is wider than this the sub-base can be crowned slightly, just enough to give the same 5 inches at the side and 7 inches at the crown.

The forms are usually made of 2-inch plank securely staked to line and grade. If much work is to be done it is economical to have the upper edges bound with steel. Concrete in a road is subject not to a gradual pressure as it is in most other forms of construction, but to a series of sharp short blows over a very small area. It is, therefore, necessary that the mixture be quite strong. The proper proportions should be determined in each individual case, but experience has taught that nothing leaner than one part Portland cement, two parts sand and four parts gravel or broken stone should be used, and this only when the aggregates are properly graded to secure the maximum density. An excess of mortar is required to hold the large aggregate rigidly in place, and in Wayne county they are now using a mixture as rich as 1: 1½: 3. The concrete should be mixed quite wet for ease of workmanship and the proportions should be exactly determined for each batch, and a uniform amount of water should be used.

Several types of mixers have been used for concrete road construction. A continuous mixer should never be employed. The traction type with a swinging boom extending in back and arranged so that a bucket runs from the mixing drum to the end of the boom is probably the most popular. With such an arrangement the concrete can be deposited the full width of the road with a minimum of re-handling. These booms are usually made about

20 feet long so that it is only necessary to move the mixer once to every eighteen linear feet of road constructed.

Mixers with inclined chutes have been employed; also stationary mixers moved at more or less infrequent intervals, the concrete being distributed by means of wheelbarrows, two-wheel buggies, or horse-drawn concrete bottom-dump carts. During the placing of the concrete particular care should be exercised to prevent disturbing the rolled sub-base.

Fig. 5.

Showing the Template used to strike off the Crown of the Road; the Baker Plat being kept in position to Protect the Edge of the Joint by means of T Installation Device and a Type of Mixer with Chute for Economical Construction.

As soon as it is placed and spread the concrete should be struc off by means of a template cut to the proper shape of the roa This rides on the side forms and where possible is drawn forwar with a sidewise motion to produce an even surface. It is usuall made of a 2″ x 8″ plank about two feet wider than the road an with the lower edge steel bound. Very little tamping is necessar to bring mortar to the surface and this can all be done with th

template. As a rule a small amount of floating must be done to remove any rough or irregular places left after using the template. A wooden float should be used. The time between using the template and floating depends upon the condition of the weather, but is usually about one hour. Care should be taken not to over-trowel, which will bring to the surface too much fine material.

Floating should be done from a suspended plank or bridge spanning the road and resting upon the side forms. Then there will be no danger of disturbing the wet concrete by placing planks upon it or by the finishers trying to take in too large an area without moving, which involves stepping upon the surface. Such a bridge is cheap and has the added advantage of allowing the workmen convenient passage from one side of the road to the other.

The edges should be beveled when the concrete has hardened sufficiently, if stone or earth shoulders are to be built.

To be safe in case of sudden rain, a hot sun or high wind, at least one hundred feet of canvas should be on the work. When used it should not be allowed to touch the concrete.

When the concrete is sufficiently hard to resist pitting of the surface, it should be sprinkled with water. This cannot usually be done until the day following the laying. At this time the surface should be covered with about two inches of dirt or sand, which must be kept continually wet for one week.

It is very essential to cover and keep wet a newly made concrete road. If this is not done, the concrete will not have sufficient strength to withstand the stresses brought about by contracting while hardening, and cracks will appear. These may not be harmful but they are unsightly and they cause the road to be unjustly condemned.

In a concrete road it is necessary to provide what are known as expansion or contraction joints, which are spaced from 25 to 35 feet apart. The most economical distance has not yet been determined, but these distances are used by engineers based upon the best results which have this far been obtained. All joints should be made about ¼-inch wide and filled with some elastic medium. It is advisable to protect the edges of the joints with several steel plates.

Ordinary country traffic does not require a very wide road. By the use of concrete a road can be built which will meet the re quirements and in order that vehicles may pass without getting

into the mud it is advisable that a stone or gravel shoulder, from two to four feet wide, be built along each side. The shoulder should be of the same depth as the concrete, but need not be of very strong construction, since it has to bear the weight of only one wheel now and then.

In determining the amount of traffic a newly constructed road which is to take the place of one badly worn out, is likely to be called upon to bear, judgment must be exercised. The new road will attract a great deal more traffic than did the old road, and this must be provided for.

In certain cases engineers have deemed it advisable to apply a

FIG. 6.
A Concrete Road in Minneapolis, Minnesota.

thin bituminous wearing course to the surface of the concrete road. Usually about one-third of a gallon to the square yard is used, the bitumen being applied hot, either from buckets or sprinkling cans or from tanks under pressure.

With the latter method, by means of which bitumen is impinged on the concrete under a pressure of from forty to sixty pounds, the best adherence is secured. While the surfacing material is still hot, it is covered with a layer of grit or pea gravel, sufficient material being used to absorb any excess of bitumen.

The greatest objection to a road built in this way arises from the fact that there is a feeling on the part of those building the road

that the concrete simply acts as a foundation, and that for this reason a considerably leaner mixture can be used than would be the case in a road where the wear comes directly upon the concrete.

As a matter of fact the bituminous surface invariably wears off in patches. These patches are not immediately repaired, and if the concrete is not made sufficiently rigid a hole or rut forms under traffic which often causes an unjust condemnation of concrete roads. I have noted many instances where the first concrete paving was covered with bitumen. At the end of the first year this coating has worn off to a greater or less extent and the next year's work is usually placed without any bituminous covering whatever.

In some localities it is difficult to obtain an aggregate of suitable quality for the wearing course of a concrete road. In such cases the difficulty can be overcome by building what is known as two-course work. This consists of a base mixed in the proportion of 1 part cement, 2 parts sand and 4 parts aggregate, upon which is placed a wearing course about two inches thick of imported aggregate. The proportions in which the wearing course is to be mixed depends to a great extent upon the quality of the aggregate used. As a rule a rich mixture is employed, usually about 1 part cement, 1 part sand, 1½ parts aggregate. The aggregate is generally somewhat smaller than that used for the base or for one-course work. The second course should always be placed as soon as possible after the base has been laid. In no case should an interval of more than thirty minutes elapse between the laying of the two courses.

In order to obtain satisfactory results a perfect bond must be secured between the two courses. This cannot be done if any dirt or foreign matter is tracked over the first course before the wearing course is placed. For roadways or streets over 20 feet in width reinforcement is used in the concrete.

The method of construction in this case is to lay a thickness of about 4 inches of concrete; upon this is spread the reinforcement and, as soon as possible, the balance of the concrete necessary to bring the road up to the proposed grade is placed. In this case also particular care must be exercised to secure a perfect bond between the two courses, and the finished surface must be laid within thirty minutes after placing the concrete under the reinforcing.

The best type of reinforcement to use is a wire mesh with the heavy strands running transversely across the road. The reinforcement is laid so that it does not cross the joints in the road.

The enormous increase in the yardage of concrete roads throughout the United States proves that its advantages are being rapidly recognized by highway engineers.

DISCUSSION.

CHAIRMAN.—It is generally considered among engineers that the concrete road is the ultimate solution of the road problem, but it has also been generally felt that it has been passing through an experimental stage, and most of them are willing to let the other fellow do the experimenting; but that stage is past, and the continued use of this road in the future will be marked.

MR. W. A. McINTYRE.—I did not expect to say anything, but to open the discussion, I might state the fact that there are several other types of what may be called concrete roads other than those which Mr. Ferguson has mentioned. One consists in the laying of a macadam road without the binder course, and the addition thereto of a 1: 1 sand and cement grout. After the grout has been applied and before it has set the road is rolled. This is known as the Hassam pavement and bears the same relation to the concrete pavement that the penetration method in bituminous construction bears to the mixed method. This type has been in some cases a success, and in others not a success. The difficulty seems to be a lack of knowledge as to the amount of penetration obtained.

There is another class of pavement known as the Blome pavement; one type the Granitoid and the other the Granocrete. The first is marked off in 4½" x 9" blocks, with a base of a 1: 3: 4 mixture 5¼" thick. The top course is 1¾" thick made in the proportion of 1 to 1½. The aggregate in this course is of granite or other hard rock and is graded in size using 50% of ¼" size, 30% of ⅛" and 20% of ½". The top is placed within 30 minutes after the laying of the base. The granocrete type is practically of the same construction, but the surface is not blocked.

There are other modifications of the concrete pavement; one is known as Silica, and has been used only in Duluth; another is Vibrolithic, a 1: 2: 4 mixture, over which planks are placed before the concrete hardens. A motor set on wheels is moved back and forth over the planks causing vibrations which compact the concrete and according to the inventor reduce the coefficient of expansion and consequently fewer cracks should appear. The joints can therefore be placed further apart.

It may be interesting in this connection to note some experiments made in Washington, D. C., by the Office of Public Roads. Mr. Page, the director, aid about 4500' of pavement without any joints whatever. Many engineers would say that such a pavement would buckle. Such a condition, however, did not arise. One section was laid with gravel as the coarse aggregate, another section with trap rock and a third with limestone. The contraction cracks in the gravel averaged 45 feet apart, in the trap rock 60 feet, and in the limestone 160 feet apart. There has, as yet, been no explanation as of why such a dif-

ference should occur with the different aggregates; all the sections were laid of the same consistency and by the same men in the same manner.

Mr. Ferguson brought out the fact that the sub-base must be as nearly perfect as possible. It must be absolutely smooth, so that there will be every opportunity for a free movement of the concrete after it has set. In this way only can we be assured that cracks will not appear.

CHAIRMAN.—Has the flat sub-base absolutely done away with the longitudinal crack?

MR. McINTYRE.—No, not entirely. Probably 90% of the construction now is with the flat sub-base, and it has to a great extent cut down the longitudinal crack.

MR. W. C. FURBER.—Why is a concrete road not hard on horses' feet?

MR. FERGUSON.—A horse secures a very even and firm footing when he places his feet on a concrete road. On roads which are built of stone, the horse is likely to place his foot on a loose stone, which tends to throw it to one side or the other, straining his knee or his shoulder. The question of hardness is to a great extent a question of being accustomed to a given type of road. You do not hear any complaints of brick or belgian blocks being too hard. I think Delaware avenue is paved with belgian blocks, and many of the streets in New York are paved with belgian blocks where they have the heaviest traffic, and no one complains of hardness. It is not so much a question of hardness as it is of the horse being able to place his feet on an even surface. So many of our surfaces are constructed with an excessive crown that it is almost impossible to drive horses over them with safety.

MR. E. M. NICHOLS.—Do you not think the speed of the animal has something to do with it, as well as the surface?

MR. FERGUSON.—Perhaps the speed of the animal has had something to do with it. You might have noticed, however, in one of the pictures I showed a horse turning the corner at a gallop. At Albany, New York, there is a concrete road. A man who has retired from business and spends most of his time driving fast horses uses this road a great deal, and stated that it was his experience that no injurious effects were suffered by horses traveling over it at a rapid gait.

MR. NICHOLS.—I imagine a horse would not go very fast over a block pavement.

MR. FERGUSON.—No, but the horse puts his feet down solidly and with great force. Horses travel at high speed over brick pavements. The high tractive resistance of a block pavement reduces speed.

A MEMBER.—Would not the less tractive effort required on a concrete road have something to do with it?

MR. FERGUSON.—Yes, it would have a great deal to do with it, and in that connection I have had some rather interesting experiences. Out in Wayne county a man, who was driving on a concrete road, was asked if he did not find that road injurious to the horses, and his answer was no, in no way whatever, and

that it was perfectly satisfactory. One farmer said, "I know it wears out the horses' shoes somewhat, but I now only have to have one horse to pull the same load that I used to pull with two, and I would rather buy shoes than horses."

It is quite interesting to go out and interview the men who are using these roads, and that is the best evidence of the advantage of any type of construction.

One of our engineers who was out on a section of concrete highway, had a university professor with him, and this professor was making very careful notes of the answers to the questions put to the men who drove along the roads. The first one interrogated replied that they were perfectly satisfactory, and four or five others gave the same answer, until the professor turned around and said, "I guess you have the whole bunch fixed."

CHAIRMAN.—Would you not always put a longitudinal joint in a 40-ft. road?

MR. FERGUSON.—No, not necessarily. There have been 40-ft. wide roads built. The best practice is to use reinforcement when the road is over 25 feet wide. If near that width the main body of the concrete can be narrowed by building a wide gutter.

MR. ALLEN.—How far apart do the cracks come—the transverse cracks?

MR. FERGUSON.—That depends upon the condition of the sub-base and the strength of the concrete. The transverse cracks come naturally anywhere from 45 to 160 feet apart. These cracks, however, after a year's use, when filled with tar, give no trouble at all and produce an even and satisfactory surface.

A MEMBER.—Is there not any serious wear on concrete roads which have been used for a number of years?

MR. FERGUSON.—I would not say there is no wear, but a number of concrete roads after years of wear are in perfect condition. I have seen concrete roads that have been used for five years without any steel plates at the joints which are in perfect condition today.

MR. NICHOLS.—With no appreciable wear?

A.—There has been about 1-16", that is all.

MR. S. M. SWAAB.—Would you recommend it as a pavement for a city street.

A.—It depends upon the character of the traffic that goes over it. Under certain classes of traffic you must put down some kind of surface that can be replaced as fast as it wears out, supporting it on a firm foundation.

MR. SWAAB.—I am looking at it more from the point of view of the repairs. It may be necessary to take up the street for drainage and other things, and have to repair it afterwards.

A.—We do that right on Broad street every day.

MR. SWAAB.—It would be hard to dig up a trench and in putting it back get the sub-base absolutely level.

A.—I have seen many concrete streets where patches have been made. If you will make a patch intelligently by taking all the loose material from the edges of the fracture and scrub the surface thoroughly to remove every particle of dust, and then wet it before the fresh concrete is placed, it is difficult after a year's wear to find out where that opening had been made.

Mr. Carney.—We have been making some roads with joints at different distances apart. Suppose you have a short length, could you determine what length it was necessary to put the joints apart?

Mr. Ferguson.—I think the only way is to try different lengths. So far experience shows that a spacing of from 25 to 35 feet is best.

Chairman.—That Bethayres road is in use now; has it developed any cracks?

Mr. Ferguson.—It did before the bituminous surface was spread on the concrete. I hope that as fast as any patches wear off it will be replaced, so that the road will continue in good condition. Especially should this be done at the cracks.

Mr. Allen.—What is the effect of laying a concrete road when the ground is frozen.

A.—We do not do that.

Mr. Allen.—I read an article in the Good Roads Bulletin written by Mr. Green about the Wayne county roads—are you familiar with that article?

A.—Yes.

Mr. Allen.—It speaks of cracks that have to be filled every six months.

Mr. Ferguson.—The best answer to Mr. Green's article is, that this year there were constructed in Wayne county 30 miles of roads, and the people gave the commissioners more money than they could spend for further extensions. They are more than satisfied with what they are getting. The same commissioners have been reelected several times since they started to build concrete roads.

Mr. Allen.—Have you seen the Wayne county roads?

A.—I have seen every one of them.

A Member.—Is that stretch of road between Mount Clemens and Detroit concrete, and has it disintegrated?

Mr. Ferguson.—Woodward avenue extends out from Detroit through Wayne county and into the next county. The work of the Wayne county commissioners stops, of course, at the edge of their county. The adjoining county has a bituminous macadam road, laid last year as an extension from the concrete. This macadam, built in 1912, has disintegrated very badly. I think that is what you must refer to

Mr. McCrudden.—Have you any successful concrete roads in the vicinity of Philadelphia?

A.—There is one in Chestnut Hill, built about four years ago. The other road I had reference to is on the Morris turnpike, in Warren county, New Jersey, built about one and a half years ago. Within the last few months there has been one finished at Beth Ayres. The one at Chestnut Hill is of the Hassam type.

CHAIRMAN.—What do you consider the maximum grade on which this concrete surface can be laid on an ordinary country road?

A. It is difficult to say; the Warren county road has a 6% grade. In Connecticut we have just finished a road with an 8% grade. We have another with a 14% grade. At the bottom of this steep grade there is brick paving on an 8% grade. The horses travel easily over the concrete, but as soon as they strike the brick they have difficulty in keeping a foothold. As a matter of fact I do not like to see much over a 7% grade.

A MEMBER.—How would you provide for transverse expansion and contraction on a curve?

MR. FERGUSON.—With radial joints about ¼" wide filled with some kind of elastic material. I spoke of the shrinkage of concrete—concrete contracts in setting about as much as would be caused by a reduction in temperature of 114°. When a concrete road shrinks and forms joints, the joints, under traffic, fill up slightly with smaller particles, and when the concrete expands again it cannot take full advantage of the amount of contraction that has gone on in it. We, therefore, construct artificial joints ¼-inch wide and fill them with some kind of elastic material.

A MEMBER.—Is it of advantage to add oil to the concrete?

A.—No. Mr. Page did so, but I think his idea was that it would reduce the number of transverse cracks.

CHAIRMAN.—Was not his idea to add resiliency too?

MR. FERGUSON.—That was his idea also.

MR. NICHOLS.—You were speaking of the irregularity of the transverse cracks in that street. Don't you think the method of mixing the concrete has had as much to do with it as anything else? There can be quite a variation in the proportions, even with ordinary care in mixing.

MR. FERGUSON.—Yes, that is so. Particular care must be exercised in securing proper proportions and proper mixing. In many instances concrete mixers have measuring tanks for water. Even the amount of water in each batch should be the same.

MR. NICHOLS.—Will there not be more in one batch than in others? Assuming you have the exact proportions in each batch, is there not apt to be some variation between the batches owing to the method of handling?

MR. FERGUSON.—There are not any more variables entering into the construction of a concrete road than there is in the asphalt wearing surface.

Mr. J. C. Wilson.—What sort of a county is this Wayne county that can afford to build those 90 miles of roads?

Mr. Nichols.—It is where they build the Ford automobiles.

Mr. Wilson.—The bonds on roads, I understand in many cases, last about five times as long as the roads do. The question is in reference to an ordinary community, how they can afford to lay cement roads and how they can afford to keep on laying macadam roads—for the reason stated, that they give out too fast. As I understand the figures, the cement road costs about 25% more than the macadam road. Is that right?

Mr. Ferguson.—A little bit more than that. You can build an ordinary macadam road for about 85c per square yard. A concrete road costs about $1.25 per square yard.

Mr. Wilson.—Then the maintenance can almost be included in the concrete road.

Mr. Ferguson.—That is one point we make.

Mr. Silliman.—Would you recommend a concrete street for a street like our Tioga street, for instance, 26 feet between curbs? With no street car tracks on it? If so, what sort of mixture would you use, and what thickness of concrete would you advise, and would you advise putting a bituminous surface on that concrete. Also what arrangement of expansion joints?

Mr. Ferguson.—In answer to the first question, I would recommend concrete for that street.

As to the thickness, I think that a thickness of 7″ in the center and 5″ at the side would be sufficient. For a 26-foot street I would use reinforcing. As far as tearing up the street for public utility purposes is concerned, a concrete street can be patched as well as any other street. It simply requires more care and more ability on the part of those in charge of the roads; more inspection of the work actually being done.

A Member.—Is the life of concrete paving any more than ten years?

A.—It is when properly constructed.

Mr. Carl Hering.—In what way does a concrete road give out?

A. If the slight amount of maintenance work necessary is not done on a concrete road, wear will occur at the joints and holes are likely to form here. The life of the road will depend upon its original construction to a great extent.

A Member.—Is that Baker plate entirely discontinued now?

Mr. Ferguson.—No, it is very popular.

The installing device used with Baker plates consists of a T iron which spans the road and rests on the side forms. In the bottom flange of this T there are lugs. The plates with tar paper or felt between them are clamped securely between the lugs before placing in position in the road. The installer is bent

to the crown desired and the plates are therefore held in the proper position s that their top edges are flush with the finished surface of the pavement. As soon as the concrete becomes sufficiently firm the lugs are loosened and the iron removed.

MR. ELCOCK.—The speaker made reference to the engineer corps walking o the Selinsgrove road. I had the pleasure of walking on that road, and it seeme to fill every requirement. There were some surface cracks filled with tar. Cou you tell us when this road was built?

A.—In 1911.

MR. SCHMITZ.—What is the cost of the Baker plate per square yard?

A.—About 6 or 7c per square yard.

ABSTRACT OF MINUTES OF THE CLUB

Regular Meeting, September 20, 1913

The meeting was called to order by President Taylor at 8.20 p. m., with 97 members and visitors in attendance. The minutes of the business meeting, held June 7, 1913, were approved as printed in abstract.

The Secretary announced that the Board of Governors, at their meeting on September 18, had elected the following:

To Active Membership—Guilliaem Aertsen, Robert E. Carney, Charles F. Puff, Jr., and Edmund F. Saxton. To Associate Membership—Lee Terhune Ward.

The President announced that with the money donated by the Junior Section new books had been purchased for the library, which were now on the shelves and formed a very valuable addition to the library.

Mr. Charles F. Mebus presented the paper of the evening, entitled, "Sewage Treatment in Pennsylvania," which was discussed by Dr. Henry Leffman, John C. Trautwine, Jr., and Emile G. Perrot.

Mr. John C. Trautwine, Jr., explained the theory of water hammer, which was discussed by Henry E. Birkinbine, Dr. Henry Leffman and P. A. Maignen.

Regular Meeting, October 4, 1913

The meeting was called to order by President Taylor at 8.35 p. m., with 78 members and visitors in attendance. The minutes of the regular meeting, held September 20, 1913, were approved as printed in abstract.

The President announced on behalf of the House Committee that instead of the usual annual Smoker, a monthly Smoker would be held, on the fourth Saturday evening of each month, the first monthly Smoker would be held on October 25, 1913, to which all members and their friends are cordially invited.

Mr. W. G. Button presented the paper of the evening, entitled "The Limitations of Mathematical Theory Applied to Engineering," which was discussed by John C. Trautwine, Jr., Manton E. Hibbs, Henry H. Quimby, Henry Leffmann, W. P. Taylor, S. M. Swaab, John G. Brown and Carl Hering.

A unanimous vote of thanks was extended to Mr. Button.

Business Meeting, October 18, 1913

The meeting was called to order by Vice President Swaab, at 8.30 p. m., with 173 members and visitors in attendance.

Dr. Henry Leffman presented the paper of the evening, entitled "Modern Color Photography," which was discussed by Mr. Henry Hess.

Regular Meeting, November 1, 1913

The meeting was called to order at 8.30 p. m. by President Taylor, with 68 members and visitors in attendance.

The minutes of the meeting of October 18, 1913, were approved as printed in abstract.

Mr. Bernard J. Newman, Secretary of the Philadelphia Housing Commission, presented the paper of the evening, entitled "Colossal Waste Due to Bad Municipal Engineering," which was discussed by President Taylor, B. A. Haldeman, W. C. Furber, C. F. Puff, Jr., S. M. Swaab, John C. Trautwine, Jr., and Fritz Bloch.

A unanimous vote of thanks was extended to Mr. Newman for his excellent paper.

Business Meeting, November 15, 1913

The meeting was called to order at 8.30 p. m., by President Taylor, with 112 members and visitors in attendance. The minutes of the meeting of November 8th were approved as printed in abstract.

The Committee on Nominations presented the following nominations for officers of the Club for the year 1914: President, S. M. Swaab; Vice President, J. A. Vogleson; Secretary, H. L. McMillan; Treasurer, J. Reese Bailey; Directors, J. H. M. Andrews, E. J. Dauner, F. C. Dunlap, Henry Hess.

The Secretary announced that the Board of Governors had elected to membership the following: Active—Herman E. Beyer, L. L. Gerstenberger, Charles R. Weiss; Associate—J. Hansell French, Thos. F. McBride; Junior—Charles G. Thornburg.

Mr. George A. Harwood, Chief Engineer, N. Y. C. & H. R. R. R., presented the paper of the evening, entitled, "The Grand Central Terminal Improvements," which was discussed by Messrs. John C. Trautwine, Jr., W. Copeland Furber, E. B. Temple.

A unanimous vote of thanks was extended Mr. Harwood for his excellent paper.

Business Meeting, December 6, 1913

The meeting was called to order by President Taylor, at 8.30 p. m., with 117 members and visitors in attendance.

Mr. Ralph N. Wheeler, Division Engineer, Board of Water Supply, New York, presented the paper of the evening, entitled "The Hudson River Crossing of the Catskill Aqueduct." A unanimous vote of thanks was tendered Mr. Wheeler for his interesting and instructive paper.

Business Meeting, December 20, 1913

The meeting was called to order at 8.30 p. m., by President Taylor with 165 members and visitors in attendance.

The Secretary announced that the Board of Governors, at their regular meeting on Thursday, December 18, 1913, had elected the following to membership: Active—Stephen H. Noyes, Herman V. Schreiber, A. M. Van Osten; Junior—Henry Voigt, Ragnar E. Hasselgren, Conrad W. Hallowell.

Mr. Lewis R. Ferguson, Assistant Secretary of the American Portland Cement Manufacturers, presented the paper of the evening, entitled "Concrete Roadways," which was discussed by Messrs. W. P. Taylor, J. S. McIntyre, L. T. Ward, H. C. Berry, R. E. Carney, E. M. Nichols, J. C. Wilson, F. Bloch.

ABSTRACT OF MINUTES OF THE BOARD

REGULAR MEETING, SEPTEMBER 18, 1913

Present: President Taylor, Vice President Plack, Directors Gilpin, Vogleson, Berry, Haldeman, Yarnall, Hibbs, Snook, Worley, the Secretary and the Treasurer.

The minutes of the regular meeting of May 15th and the special meeting of June 19th were read and approved.

The Secretary reported the death of Mr. R. A. Shillingford, and the Treasurer was instructed to charge off his dues for the last half of 1913.

The Treasurer reported a net gain to September 1st of $2,493.99, as compared with $862.39 for the same period of 1912.

The House Committee's report was read and approved.

An appropriation of $150 was made to the House Committee for the purpose of holding a "Club Night" in the months of October, November and December.

The Meetings Committee reported the schedule of meetings for the coming season.

The Membership Committee's report was presented and the following were elected: To Active Membership—Guilliaem Aertsen, Robert E. Carney, Charles F. Puff, Jr., Edmund F. Saxton; to Associate Membership—Lee Terhune Ward.

Mr. C. A. Bockius was transferred from associate to active membership.

Reports of the Publication and Library Committees were read and approved.

The privileges of the Club were extended to the American Mining Congress, during their session in Philadelphia, October 20th to 24th; to the American Institute of Electrical Engineers, during the week of October 13th; and to the National Fire Prevention Convention, during the week of October 13th.

The Treasurer reported that the following had been dropped from the roll for non-payment of dues: J. Frank Barber, E. H. Greenwood, A. L. Hallstrom, John G. Hendrie, L. J. F. Moore, William Oram, W. J. Pollock, T. J. Reilly, J. A. Remon, M. D. S. Stiles, H. G. H. Tarr.

REGULAR MEETING, NOVEMBER 13, 1913

Present: President Taylor, Vice Presidents Swaab and Mebus, Directors Develin, Vogleson, Berry, Haldeman, Yarnall, Gibson, Hibbs and the Secretary.

The minutes of the regular meeting of September 18th were read and approved.

Reports of the Secretary and Treasurer were read and approved.

The House Committee's report was read and approved.

The Membership Committee's report was read and the following were elected: To Active Membership—Herman E. Beyer, L. L. Gerstenberger, Charles R. Weiss; To Associate Membership—J. Hansell French, Thomas F. McBride; To Junior Membership—Charles G. Thornburg.

Report of the Meetings Committee was read and approved.

The Publication Committee presented a sample copy of material to be incorporated in the Club bulletin, and after discussion, the Committee was authorized to publish this bulletin for the next three months in place of the regular semi-monthly notice.

The report of the Publicity Committee was read and approved.

A communication from E. H. Zieber, former Junior member of the Club, was presented, in which he asked reinstatement, and the Board passed a resolution, reinstating him to membership upon the payment of dues which have accrued since his resignation went into effect.

The resignations of C. Willis Adams, Arthur F. Barnes, Allen S. Hurlburt, R. W. Hilles, H. D. Elfreth and G. W. Whiteman were accepted as of December 31, 1913.

The Treasurer reported that the following had been dropped from the roll for non-payment of dues: Geo. F. Smith, Lorenzo S. Cope, W. M. Karekin.

J. A. Vogleson and S. M. Swaab were appointed a committee to represent the Engineers' Club on the committee to make arrangements for a meeting of the various technical societies of Philadelphia and vicinity.

Regular Meeting, December 18, 1913

Present: President Taylor, Vice Presidents Plack, Mebus and Swaab, Directors Develin, Vogleson, Haldeman, Yarnall, Gibson, Snook and the Secretary and Treasurer.

The minutes of the regular meeting of November 13th were read and approved.

The Secretary reported the resignations that were before the Club and the following were accepted as of December 31, 1913: John Gwilliam, F. Thibault Gross, J. A. P. Crisfield, Charles Wirt, J. F. Buchanan, Carl H. Satherberg, Charles Wilke, David Halstead, Thomas L. Latta, Martin Stotz, G. N. Dawes, A. L. Terry, Jr., C. N. Butler, A. T. Lewis, F. F. Dickerman, Martin Nixon-Miller, Harrison Souder, C. C. Willits, George F. Pond, W. S. Evans, E. H. Robie.

The Treasurer reported a net gain of $2,592.29, as compared to $1,217.32 for the same period of 1912.

Reports of the following committees were presented and approved: House, Membership, Publication and Library.

The following were elected to membership: Active—Stephen H. Noyes, Hermann V. Schreiber, A. M. Van Osten; Junior—Henry Voigt, Ragnar H. Hasselgren, Conrad W. Hallowell.

On motion the following Junior members were transferred: To Active Membership—Edward N. Blum, C. N. Wunder, S. H. Wright, Chas. H. Schaefer, John C. Graf; To Associate Membership—Victor Shuman, James E. Diamond.

The following resolution was proposed by Mr. Gibson, seconded by Mr. Bailey and carried:

"In consideration of the cancellation of an existing contract with Mr. Ritchie, and in settlement of all agreements due him, that he be paid the sum of $500, in addition to his present salary, which is due him under his contract of May 1, 1912, and which shall include all indebtedness due him to January 1, 1914; and that a new contract be made, under date of January 1, 1914, paying him at the

rate of $2,100 per annum, to be payable in instalments of $175 per month, and that the President and Treasurer be empowered to put this motion into effect in the proper form."

The Business Manager was ordered to look up the correspondence in connection with the Evans Studio, and if there was no agreement existing between the Engineers' Club and the Evans Studio, authorizing them to use our name upon their stationery, that they be ordered to remove it therefrom.

A communication from the News Distributing Company, in reference to publicity, was presented by Mr. Hess and referred to the Publicity Committee for report at the next meeting of the Board.

Mr. Hess, as delegate to the International Conference of Safety and Sanitation in New York City, reported the result of his visit to the Conference.

Mr. Vogleson reported the results of the meeting of the Committee of Allied Societies of Philadelphia.

The Treasurer reported that Erle C. Herman had been dropped from the roll in accordance with Act VII. Sec. 1, of the By-Laws.

W. PURVES TAYLOR

36TH PRESIDENT OF THE ENGINEERS' CLUB.

Editors of other technical journals are invited to reprint articles from this journal, provided due credit be given the PROCEEDINGS

PROCEEDINGS

OF

THE ENGINEERS' CLUB

OF PHILADELPHIA.

ORGANIZED DECEMBER 17, 1877. INCORPORATED JUNE 9, 1892.

NOTE—The Club, as a body, is not responsible for the statements and opinions advanced in its publications.

Vol. XXXI APRIL, 1914. No. 2

ANNUAL ADDRESS BY THE RETIRING PRESIDENT

W. PURVES TAYLOR

February 7, 1914

The engineer of today is, primarily, an analyst of conditions. His essential function is to collect and classify data, to analyze it, and to so apply the results of his analysis as to obtain the maximum efficiency and economy in his field of endeavor. Throughout the year, many papers have been read before the Club, covering numerous and diversified phases of engineering activity, and each has consisted of a description of the overcoming of obstacles through a study of conditions and the attainment of the desired end by successfully applying the methods so determined.

In an organization such as ours, composed of engineers, the avowed purpose of which is to be of practical benefit to not only its members, but to the community, it appears especially fitting that we should at more or less frequent intervals make such an analysis of our own condition, to ascertain as far as possible whether we actually are securing the maximum benefit to ourselves, whether we are serving the community most profitably, or whether we, in any way, are falling short of the ideals towards which we are striving. Several such analyses of the condition of the Club have been made, especially in the past few years, and each of these has been prolific in helpful suggestions which have been of immeasurable benefit in the conduct of our affairs. To some of you it may appear somewhat unnecessary that these matters be brought up for considera-

tion at this time, for, unquestionably—at least from a financial standpoint—the past year has been one of the most successful in the history of the Club. No maintenance engineer, however, waits until his structure fails or until the public safety is menaced before applying his corrective remedies, but he is continually watchful for the least evidence of weakness, and anticipates the condition before the actual necessity for applying the remedy arrives. We, as an engineering body, should maintain just such an attitude, and should be continually studying, analyzing, and investigating ourselves, for only by adopting such precautions can this organization maintain its recognized position among the technical organizations of the country, and its prestige in the community.

The history of the Club is a subject with which many of you are familiar from personal experience, and which has been written in detail on several occasions, and, of course, is given in full in the minutes of the Club as published in the proceedings, so I shall pass over it but hastily.

The Club was organized December 17th, 1877, with a membership of 21, and By-Laws were adopted January 19th, 1878. The annual dues originally were $5.00. For a few months the Club had no regular quarters, its meetings being held at the houses of its members. In April, 1878, rooms were rented on the third floor of No. 10 North Merrick Street, as West Penn Square was then called, this building being on the present site of Broad Street Station. The first number of the PROCEEDINGS was issued in January, 1879. In September, 1879, the Club moved to rooms at 1518 Chestnut Street, and, later, in September, 1881, to 1523 Chestnut Street. In October, 1885, the Club moved again to 1122 Girard Street, where it remained twenty-two years, moving finally to its present house on December 31st, 1907.

The Club was incorporated under practically its present Charter on June 9th, 1892. The annual dues for Active members, beginning at $5.00, were raised to $7.50 in 1880, to $10.00 in 1890, to $15.00 in 1893, to $25.00 in 1908 and to $35.00 in 1910. The Associate grade of membership was created in 1886 and the Junior grade in 1897.

If the financial status of the Club can be taken as the sole criterion of its condition, its present state of prosperity is beyond question.

Figure 1 is an extension of the diagram prepared last year by

Mr. Hess and shows the annual income and expense and also the annual profit and loss, the hatched areas indicating profit and the solid areas indicating loss. It is unfortunate for the continuity of this diagram that no data is available for the year 1891. The great increase in the volume of business transacted by the Club showing in both increased income and expense, which occurred when the Club first moved to its present location, is clearly indicated in the diagram. The loss immediately following this move, which resulted from too optimistic calculations as to the amount of annual dues required to operate this house, is also evidenced. It is, however, clear that the volume of business handled by the

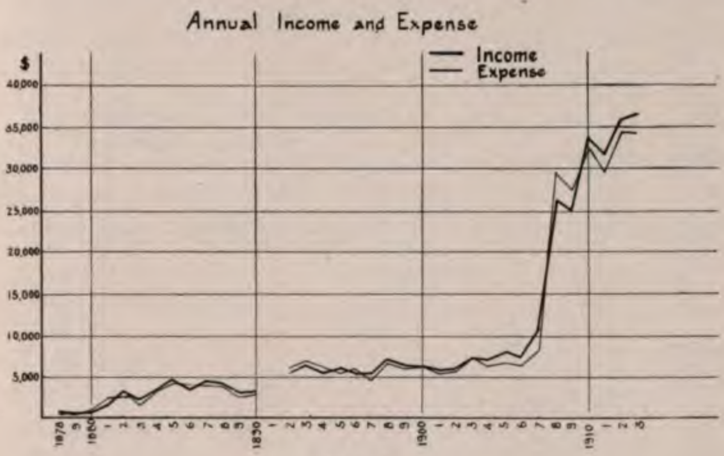


FIG. 1.

Club is steadily advancing, and that the annual profit in the past four years is regularly increasing, the annual profit of the past year amounting to \$2,671.41, this being the greatest in the history of the Club. The Club's surplus, which amounted to \$8,548.25 when it moved to 1317 Spruce Street, dropped to \$6,480.21 at the end of the year 1909, and since then has advanced to \$7,989.13 in 1910, to \$11,422.28 in 1911, to \$12,647.54 in 1912, and to \$14,178.68 in 1913. Furthermore, it should be stated that in the early period of existence in this house the assets were very liberally figured, and it is doubtful whether at a certain period the Club really had any surplus, but that condition has gradually been changed, and the present surplus as shown on the books is an actual one. Each

one of the 593 members of the Club, therefore, has an actual cash equity in the Club property amounting to $23.91, which is remarkably good, considering that the Club has absolutely no endowments of any sort, and that the recent generous donation to the sinking fund has been the only donation recorded in the history of the Club.

Figure 2 shows the annual profit and loss per member, but as the curve of the increase in membership has been fairly regular little additional information is brought out by this diagram. The fact that in 1908 the annual loss per member amounted to $6.00 clearly indicates the necessity that existed for increasing the dues

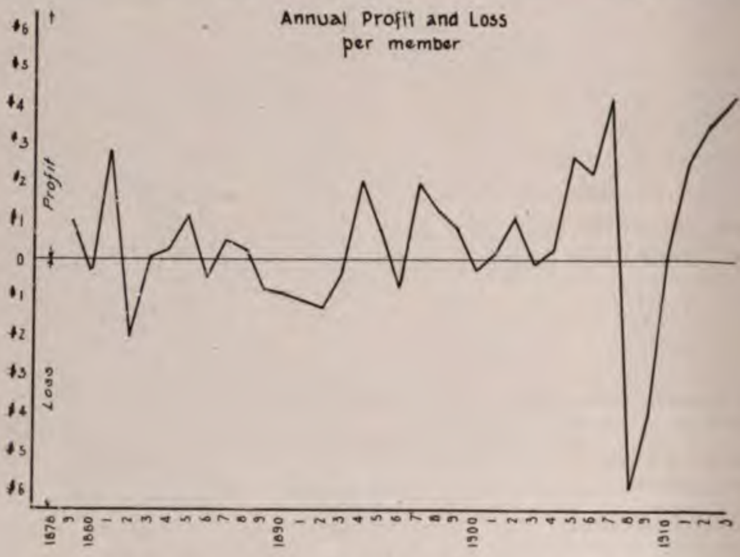


Fig. 2.

at that time. It might be considered that the present profit per member of $4.30 is unduly great, for, of course, an organization such as this should operate as nearly as possible without profit, and every dollar expended by the members should bring an immediate return to them. It must be remembered, however, that the Club carries at the present time, including its mortgage on the property, its second mortgage bonds, and its building fund notes, a total indebtedness of $73,200.00, and while it probably never will be necessary to retire the first mortgage on the property, a sinking fund must be created for the retirement bonds and the

building fund notes, and the present profit derived from the operation of the Club is little more than adequate for this purpose. The second mortgage bonds issued in 1907 amounted to $30,000.00 and the building fund notes issued in 1909 to $9,500.00, a total of $39,500.00. Since that time, there have been retired $4,750.00 of the bonds and $1,550.00 of the building fund notes, and there is at present $312.26 in the sinking fund, which indicates that these bonds and notes are being retired at a little faster rate than is necessary to entirely retire the issue at the expiration of thirty years, which is the period named in the bonds. While, of course, it would be desirable to cancel this indebtedness at the earliest possible date, the Club should not attempt to retire them more rapidly than is convenient, for this means an unnecessary crippling of the present for a questionable benefit in the future.

The value of this property is more than sufficient to protect the holders of the bonds, and if they cannot all be retired by the period of maturity, it will be a comparatively simple matter to float a new issue to the amount of the unpaid balance. It would undoubtedly be a great mistake for the Club to deprive its members

Income	1907	1908	1909	1910	1911	1912	1913
Dues and Initiation Fees	8853.75	13929.05	12764.70	17079.70	16526.96	17496.59	17985.00
Publications	1372.30	1268.49	1264.67	1532.80	1153.11	1043.55	1091.98
Lodging	....	916.47	1636.21	2607.41	3063.58	3684.73	3687.44
Rent of Meeting Room	....	....	40.00	96.00	137.50	334.00	623.00
Club-house Business	....	8298.26	7005.31	10419.39	10195.61	13119.89	13061.94
Miscellaneous	674.26	224.21	1057.44	613.77	844.07	237.85	291.19
Sale of 2nd Mortgage Bonds	16650.00						
Total	27550.31	24636.48	23768.33	32349.07	31920.83	35916.61	36740.55
Expense							
Salaries	1735.00	5299.72	5912.56	9582.65	9147.86	11742.37	11708.50
Publications	2255.91	1494.54	1767.72	1647.69	1468.95	1396.86	1485.66
Committees	258.08	710.41	1257.96	1274.78	836.13	986.26	1027.61
Fixed Charges: Interest, Taxes, etc.	1260.00	4449.40	4868.30	4717.39	4985.82	4958.31	5095.52
House: Light and Heat	347.83	1500.37	1426.10	921.92	1305.81	1727.46	1733.79
Restaurant, Wines, Cigars, etc	....	10733.99	7570.70	10300.60	9717.61	11157.15	10109.10
House	1337.14	716.94	1344.88	1492.77	1179.79	1137.91	1147.37
Office	1047.92	1434.59	526.10	417.03	388.52	427.75	642.93
Miscellaneous	13.60	1377.24	1399.72	587.23	582.19	757.83	1118.66
1317 Spruce Street	16675.56						
Total	24931.04	27717.20	26074.04	30942.06	29612.68	34290.90	34069.14

Fig. 3

of present benefits, and to lessen its usefulness in order to acquire property which will not for years to come yield a return commensurate with its cost. If $500 a yeaı were expended on the retirement of bonds and notes, it would reduce the total indebtedness of the Club, exclusive of the first mortgage, to $20,000.00 at the time of the maturity of the bonds, which could readily be met through a new bond issue, and in the meantime the operating profit of the Club could be expended in furnishing better facilities to its members.

The table shown in Figure 3 is a condensed summary of the Club's annual income and expense from the year 1907 to date.

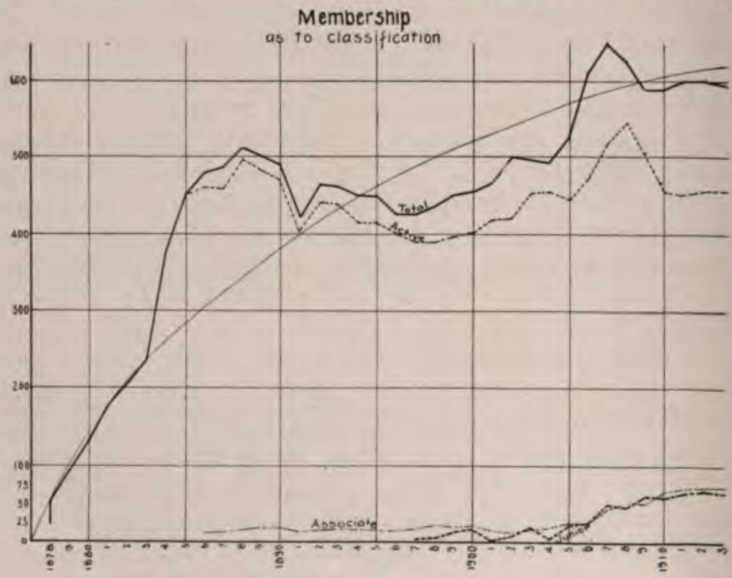


FIG. 4.

The regular increase in income derived from lodging is a clear indication of the increasing use of the house by the members, and also furnishes ample justification of the action of the Club in issuing the building fund notes used for the alteration of the house, so as to provide more sleeping rooms.

The increasing income derived from the rent of the meeting room is also especially pleasing to those who are desirous of having this Club-house become the center of the technical activities of the city. The income derived from Club-house business advances, apparently, at very irregular intervals, but, on the whole, it shows

a very good condition. You will note from this table that the total Club-house business, including lodging and rent of the meeting room, has increased 88½ per cent. in the past five years, and also that the present receipts from lodging and from the rent of the meeting room are almost sufficient to pay the fixed charges on this building. You will also note that, although the income from Club-house business has greatly increased, the expenses of the Club-house are maintained almost constant, for which our efficient House Committee should be given great credit.

The greatest increase in the expenditures is in the salaries, the two great increases being in 1910, when the Club took over the operation of the restaurant, and in 1912, when the services of a Manager were secured.

The loss due to the operation of the restaurant, which amounted to $3,900.00 in 1911, and to $3,400.00 in 1912, has been brought down to $1,789.00 for 1913, and only a slight increase in patronage will enable this department to operate at a profit.

Figure 4 shows the curve of membership of the Club since organization, and, generally speaking, shows a fairly regular and creditable advance. The marked decrease in the membership in 1891 was due to the fact that the Club had prior to that time been carrying a great many members who were delinquent in their dues, and the actual membership prior to that time was fictitious. I believe that 83 members were dropped in that one year to absolutely clear the membership list of all but bona fide members. In the present year, practically the same thing has been done, and the names of all members delinquent in their dues, or who in any way could not be considered as in good standing, have been dropped from the rolls. That this has been accomplished with such a slight loss in membership is a matter for congratulation. The classification of the membership into Active, Associate, and Junior grades is also shown in this diagram, the Associate membership being created in 1886 and the Junior grade in 1897. The increase in the membership of these two classes in the past decade is well indicated. It is especially desirable, in my judgment, that the Club make a vigorous effort to increase its Associate membership, and I believe much more could be done along this line were a vigorous campaign inaugurated to that end.

The classification of the membership as to residence is shown in Figure 5, the non-resident grade of membership being established

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in 1884. These curves indicate that the proportion of non-resident to resident members is decreasing, for while in 1886 the resident and non-resident membership were almost equal, in the present year the non-resident membership amounts only to 23 per cent. of the total. This is a natural development of a Club such as this, for its activities are, and in my judgment should be, local in their nature; and, while, of course, it is desirable to encourage non-resident membership as much as possible, I do not believe that the Club can ever hope to obtain the interest of engineers permanently residing at some distance from the city. The non-resident member-

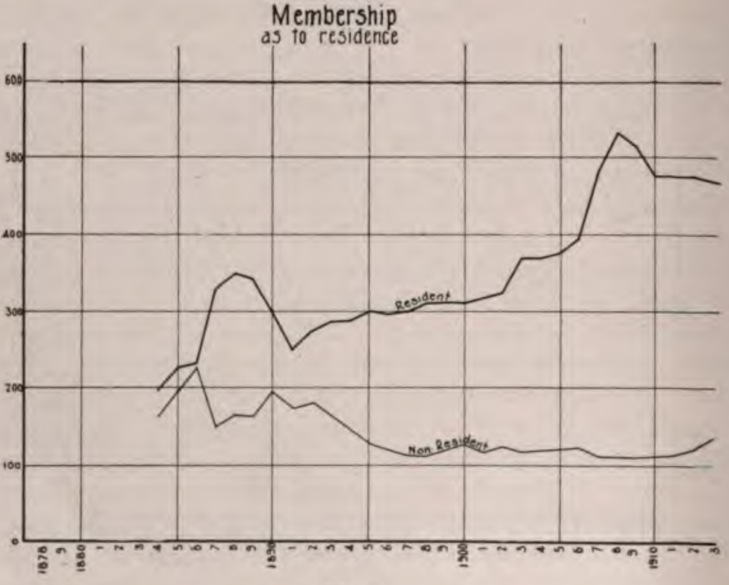


Fig. 5.

ship at the present time is largely composed of Philadelphians who are temporarily engaged in work at a distance and expect to return to resident membership in the near future, and while this grade is a useful means of retaining the membership of such engineers, it is doubtful whether others could be attracted to it, except in a few isolated cases where past associations are factors. It has been suggested that a special effort be made to obtain non-resident membership through interesting engineers of other cities in the facilities of this house as a hotel, but the men who can be so interested must, nec-

essarily, be exceptional. The future of the Club, apparently, lies in building up a strongly local institution, rather than attempting to develop an organization entitled to compete either with the national engineering societies or to compete as a hotel.

The annual gain or loss in membership is shown in Figure 6. It must be remembered that all points above the line indicate an actual gain, so that, while there is a downward slope in the curve in the period from 1884 to 1888, at the same time there was actually a gain all through this period. The greatest loss in membership to date is shown in the period of 1891, the reasons for which

FIG. 6.

have already been explained. The loss in membership in 1909 and 1910 was largely caused by the increase of dues, made necessary shortly after moving into this house.

One of the principal reasons why the Club at present has not a larger membership is its unfortunately high dues, for, while a recent report made of the Committee of the American Society of Civil Engineers shows that the average engineer who has been fifteen years in practice receives in compensation the amount of four thousand dollars, I cannot believe that such condition maintains throughout the engineering profession at large, and I am certain

that the dues that we are compelled to charge to operate our present establishment is a great deterrent to many of the younger engineers from becoming members. Our financial statement this year shows that the Club could operate its present establishment with the dues reduced from $35.00 to almost $30.00, but such a slight reduction would not be sufficient to create an additional attraction to membership.

Figure 7 is an interesting study. The portion of the diagram showing curves up to the year 1905 was prepared by Mr. Hering for use in his presidential address in that year, and the lines from 1905

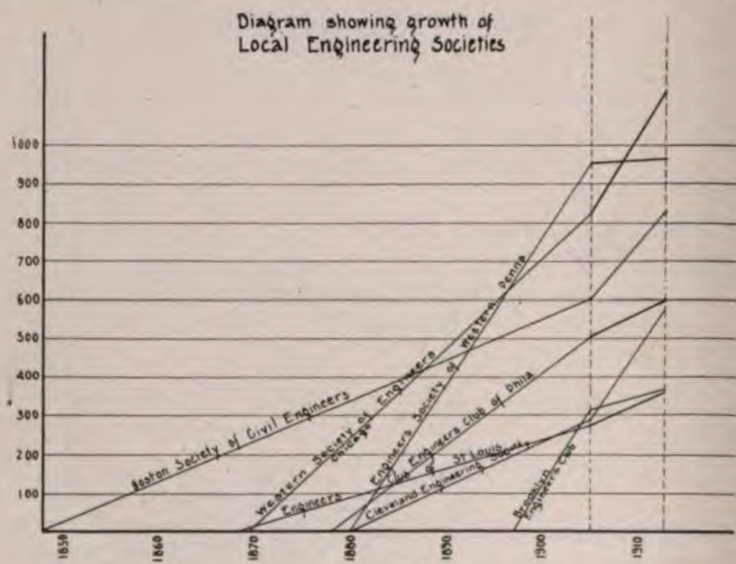


Fig. 7.

to date indicate extensions of these original curves. In Mr. Herings' diagram, no attempt was made to show the actual curve of increase, each line being drawn a straight line from the date of the organization of the society to the total membership in the year 1905, and the same method has been pursued in the extension of this diagram to 1913.

It should be stated that the 1913 figures, with the exception of this Club, were all obtained in November, 1913; and represent the condition at that time, rather than as of the first of the year. It will be noted that the line of the Engineers' Club has slightly flattened

its angle, indicating that the development from 1905 to 1913 is at at a lower rate than prior to that time. When viewed, however, in comparison with some of the other organizations, we have even less cause for self-congratulation, for, with two exceptions, each other local engineering society is increasing its membership faster than ours. The rapidly increasing membership of the Boston, Chicago, and Cleveland societies indicates a systematized effort on their part which this organization would do well to emulate.

Mr. Hering, in 1905, stated that of the original twenty-one members, four still retained their membership. These have now been reduced to two, Mr. Charles E. Billin and Mr. Wilfred Lewis.

The following, however, is a list of those who have been members of the Club for thirty years or more:

Billin, Chas. E., Dec. 17, '77, Chicago, Ill.
Lewis, Wilfred, Dec. 17, '77, Philadelphia, Pa.
Webster, George S., Jan. 18, '78, Philadelphia, Pa.
Hering, Rudolph, Feb. 2, '78, New York City, N. Y.
Lehman, A. E., Feb. 2, '78, Philadelphia, Pa.
Morris, Henry G., Feb. 2, '78, Philadelphia, Pa.
Potts, Wm. M., Feb. 2, '78, Wyebrooke, Pa.
Cooper, Wm. A., March 2, '78, Conshohocken, Pa.
Codman, John E., Jan. 18, '79, Philadelphia, Pa.
Wharton, W. Rodman, Jan. 18, '79, Philadelphia, Pa.
Gest, Alex. P., March 1, '79, Trenton, N. J.
Sheafer, Arthur W., March 1, '79, Pottsville, Pa.
Edwards, J. Warner, Oct. 4, '79, Denver, Colo.
Chance, H. M., Dec. 6, '79, Philadelphia, Pa.
Osborne, John G., May 1, '80, Radford, Va.
Reeves, David, Oct. 2, '80, Philadelphia, Pa.
Hoopes, John J., Oct. 16, '80, Vicksburg, Miss.
Ehlers, Peter, March 5, '81, Philadelphia, Pa.
Smith, Edwin F., June 28, '81, Philadelphia, Pa.
Paddock, F. L., Nov. 19, '81, Bryn Mawr, Pa.
Clement, F. H., Jan. 14, '82, Hempstead, N. Y.
De Magalhaes, A. C., Jan. 14, '82, Philadelphia, Pa.
Hering, Carl, Jan. 14, '82, Philadelphia, Pa.
Rea, Samuel, May 6, '82, Philadelphia, Pa.
Fuller, Allen J., July 1, '82, Philadelphia, Pa.
Gwilliam, George T., Dec. 2, '82, New York City, N. Y.
Hutchinson, Edward S., April 7, '83, Newton, Pa.
Hartley, Henry J., Jan. 12, '84, Philadelphia, Pa.
Trautwine, John C., Jr., Jan. 12, '82, Philadelphia, Pa.

That of the 204 members belonging to the Club in January, 1884,

twenty-nine, or 14 per cent., are still active members, is a most encouraging indication of the interest taken in the Club by at least some of its members.

Prior to 1908, the Engineers' Club existed almost solely as a technical society, and while, since that time, the social element has been introduced into the activities of the Club, nevertheless, the primary object of its existence lies in its activities as a technical organization. The technical meetings of the Club, therefore, should indicate most clearly whether the Club is actually, and in the best manner, fulfilling its avowed purposes. I think you will

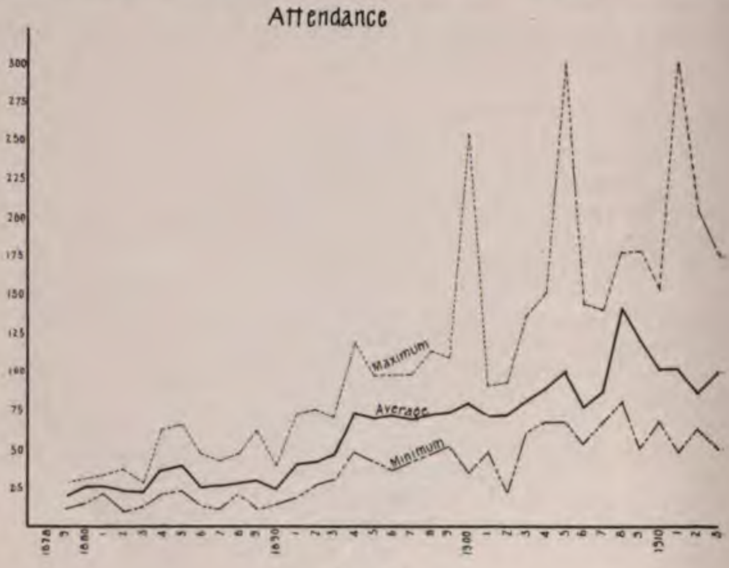


FIG. 8.

concede that the papers which have been presented to the Club in the past year have been of exceptionally high caliber, and yet, in spite of this unusual inducement for attendance at these meetings, the actual attendance, although greater than last year, is apparently tending to decrease, rather than increase.

Figure 8 indicates the average yearly attendance at the meetings of the Club, and also shows the maximum and minimum attendance at any meeting in each year. It will be noted that the average attendance showed a regular and continuous advance up to the year 1908, and, since that time, it shows a regrettable tendency to fall off.

As a matter of interest, the following list of papers has been compiled, at which the attendance exceeded 150:

February 4, 1905, John W. Hill, "Examination of the Torresdale Conduit," 303.

January 4, 1908, F. B. Maltby, "Dredging Equipment of the Panama Canal," 179.

February 1, 1908, Joseph W. Hunter, "Engineering Problems in Road Construction," 173.

February 15, 1908, W. L. Wilcox, "Recent Improvement of the Incandescent Lamp," 156.

March 21, 1908, Grafton Greenough, "The Mallet Type of Locomotive," 150.

April 4, 1908, John C. Trautwine, Jr., "Socialism as illustrated by Papers recently presented before the Club." George M. Heller, "Design of the Centering for the Main 232 feet Concrete Arch Span, Walnut Lane Bridge, Philadelphia," 175.

May 2, 1908, S. M. Swaab, "Construction of the East Market Street Subway," 180.

May 16, 1908, W. S. Reed, "Sand—Its Use and Application in the Various Industries and Processes," 158.

December 19, 1908, Paul W. England, "Underground Conduit," 170.

March 6, 1909, Manton E. Hibbs, "Hammerstein as a Builder," 155.

April 3, 1909, A. Fred Collins, "Wireless Telegraphing and Telephoning," 180.

November 6, 1909, A. M. Hering, "A Few of the Engineering Problems Involved in the Design of the Aeroplane," 179.

February 15, 1911, George W. Goethals, "The Engineering Features of the Panama Canal," 300.

October 21, 1911, John W. Ledoux, "The Failure of the Austin Dam," 189.

November 16, 1912, Henry M. Neely, "The Mechanics of the Aeroplane," 205.

December 20, 1913, Lewis R. Ferguson, "Concrete Roadways," 165.

The high point shown in the diagram in 1900 was occasioned by an Anniversary meeting held December 15th, at which 86 members and 173 visitors were present. It is probably not altogether proper to include this meeting in a study of attendance.

Without wishing to detract in any way from the value of the papers presented early in 1908, the large attendance at some of these meetings, however, can be attributed to the fact that the Club had just moved into its new quarters, and undoubtedly many of those attending these meetings came through a desire to see the building, as much as to attend the meetings. The writer attempted to construct a diagram which would show how the attendance varied with the character of the paper presented, but was not successful in making a diagram that would clearly indicate

the facts. A study, however, of the attendance makes it obvious that the greatest attendance is obtained when the subject for discussion is one which is of public interest at the time of presentation. This fact is brought out especially through the large attendance at the meeting in 1905, when Mr. Hill presented a paper on the Torresdale Conduit, which was at that time the subject of investigation, and on which much was being written in the daily press. A greater effort should be made by the Club to bring before it matters of local public interest, which not only will result in better attended and more interesting meetings, but will materially benefit the Club through the publicity obtained.

Of the different phases of Club activity, the library is probably the one that at present time is in greatest need of improvement. Prior to last year, when a number of books were purchased from funds donated by the erstwhile Junior Section, there had been no books purchased for a period of six or eight years. The present arrangement of the library is unfortunate, and the Board of Governors is now contemplating making improvements which will not only add to the appearance of this room but will make it both more comfortable and more serviceable to the members of the Club. I do not believe that the Engineers' Club should endeavor to maintain a complete general library along all the different fields of engineering work. The intense specialization which modern conditions demand of every engineer makes necessary that each man's own library is more or less complete in his special field, and all that he, as a rule, needs, outside his own collection, are general reference books and reports. The Library Committee should make special endeavor to keep our ordinary engineering reference books complete and up to date at all times, and further effort should be made to obtain as far as possible all the reports issued by the national state and municipal governments—reports of experiment stations, etc.—and should keep these so indexed and so accessible that they are easy of reference. The filling of periodicals is also a matter that should be given more careful attention. While, at the present, a certain number of the more important periodicals are regularly bound and filed, this number should, undoubtedly, be considerably extended. Should the financial condition of the Club ever become such that a good general library could be obtained, it, of course, would be an extremely valuable asset, but even with the funds available at present, a well organized effort, combined with specializing

along the suggested lines, could make the library of much greater value to the members of the Club than it has been.

The PROCEEDINGS of the Club are one of our most valuable assets, and as an instructive record of the development of engineering in the past three and a half decades they are most interesting. Begun in 1879, they have been continuously published, and the subject matter contained in them is of unusually high caliber. It must be admitted, however, that the value of the PROCEEDINGS is, principally, as a historic record, as, at the present time, the technical periodicals cover so thoroughly and actively the entire engineering field. Our PROCEEDINGS, therefore, are chiefly of interest from either the personal, the local, or the historic standpoints, and it is questionable whether the subject matter, valuable as it is, is sufficient to make the PROCEEDINGS of interest to anyone not actually connected with the Club and active in its local affairs. The question of how these PROCEEDINGS may be made more attractive, while maintaining their character, and without violating the associations and traditions connected with them, has been frequently discussed of late. The earlier issues of the PROCEEDINGS contained a number of notes and communications pertaining to current engineering events which now have a great historic value, and which, at the time, were undoubtedly of considerable local interest. This practice has not been continued in recent years, and whether more concerted effort should be made to obtain such extraneous matter is a question that should be seriously considered. In the endeavor to obtain a medium of communication with the members of the Club, which would be of more immediate and personal interest than the PROCEEDINGS, the experiment has been made of issuing the Club *Bulletin*, which is intended to supplement the PROCEEDINGS, by sending the members such communications, notes, and other matter as may be brought before the Publication Committee. The issue of this *Bulletin* was authorized for a period of three months, and if the experiment proves successful at the end of that time, it is to be continued and expanded, if possible.

One other question relating to the PROCEEDINGS of the Club is that of including in these PROCEEDINGS the papers presented by other organizations which have this Club as their headquarters, and which do not issue regular publications of their own. It is believed that interesting matter could be obtained for the PROCEEDINGS through these other societies, and, really, the only objection to their inclu-

sion is a conservative dread of somewhat destroying the traditions of our own publication. There is much to be said in favor of such an extension of our PROCEEDINGS, for it is thought that by such means not only their value and interest would be much enhanced, but, from a business standpoint, it is believed that the increased circulation, and the increased advertising that would become possible by reason of this increased circulation, would be almost in itself sufficient reason for such action. The whole subject of the Club publications has, during the past year, been given especial attention, and a continued endeavor should be made to develop some means of reaching the members in a more live and personal way, while still maintaining our traditions.

When, in 1907, the Club moved to its present location and assumed the functions, not only of a technical society, but also of a social Club, it, undoubtedly, made the most momentous change in its career. Immediately following this change, the patronage of the Club-house was extremely good, caused, of course, largely by the novelty of the use of such a Club. This, in the first year, rapidly dropped off, as the novelty disappeared and before the members had become accustomed to making regular use of the building. During the past five years, however, the growth in patronage of the Club-house has been regular, and while the Club is still not used to the extent that is desirable from a standpoint of financial operation, it has advanced sufficiently to indicate beyond question that the members of the Club desire a social, as well as a technical Club, and the wisdom of making the original change in the Club's functions has been clearly established. The use of the sleeping rooms, which at first was only nominal, increased so rapidly that the accommodations had to be increased, and at the present time the rooms are occupied a much greater percentage of time than in even the most popular hotels. The restaurant, however, is not patronized as much or as regularly as it is desired, and it is difficult to determine by what means the members can be brought to the point of using the facilities provided to a greater extent. Undoubtedly, the service compares most favorably with anything that can be obtained in the city for the same price.

The location of the Club-house has often, in argument, been given as the reason why the Club is not more regularly used, and it is possible that this is a considerable factor, for the city of Philadelphia is peculiarly provincial in its attitude, in requiring all

its facilities to lie within an extremely restricted area. Undoubtedly, however, the location of the Club is one that will become increasingly popular, and it is not felt that this objection is one that will remain permanently.

The foregoing statements indicate the Club's present condition, and it is easily seen that, while the Club's present financial condition is undoubtedly good, in other respects there is much improvement possible. The corrective remedies that may be applied to meet these less fortunate conditions depend, of course, primarily on the function that the Club is to assume in the future, and while it is not necessary that any definite action of either the Club or the Board will be taken to determine this function, nevertheless, a certain policy of development should be established, as there seem to be two distinct ways in which the Club may be developed, and that if it is to develop it must proceed on one or the other of these lines is evident. On the one hand is a Club, much as we have it, its principal activity being to provide comfort and pleasure to its members, the technical activities tending to decrease, rather than increase. Opposed to this condition, which under ordinary circumstances would seem the logical future of the Club, is an organization which has for its primary object its use to the community and to the profession, rather than the more selfish and exclusive personal interest to its members. I believe that the Club has a great possibility in extending its field of endeavor, and that it can become not only the central point of activity in engineering lines, but that it can be a distinct factor in the community in determining its policies. While an organization such as this should not attempt or assume any educational work, its endeavor should be to so reorganize and constitute itself that it will obtain the active interest of the entire profession.

One of the greatest possibilities towards increasing the scope of the Club's activities and also one of the greatest means of increasing its usefulness and its prestige in the community lies, in my mind, in effecting some sort of fusion or amalgamation with the different technical and semi-technical organizations or branches of the national societies that are now meeting in the city. At the present time, there are already eight or ten such organizations now active, including the local branches of the American Chemical Society, American Society of Mechanical Engineers, American Institute of Electrical Engineers, Illuminating Engineering Society, Aero

Club of Pennsylvania, American Society of Marine Draftsmen, Municipal Engineers' Society, Philadelphia Pharmaceutical Association, American Society for Testing Materials, etc., and others are continually forming. A local branch of the American Society of Civil Engineers has just been established. If the Engineers' Club of Philadelphia could be made the common meeting point of these different organizations, not only from the physical standpoint in providing a place for holding their meetings, but in the broader sense, so that the expression of opinion of the Engineers' Club would represent the consensus of opinion of all these different engineering bodies, this Club would then be assuming its highest possible plane. It is, undoubtedly, possible to formulate measures by which these organizations could be taken into this Club, in such a way that the Engineers' Club would assume more or less the function of a holding corporation, with the different technical societies, being in the position of subsidiary companies. If such a consolidation could be effected, any technical matters arising would be referred to the organization intrusted in that field of work, and the Club, comprising all these different societies, would only be called together when broad matters of public interest were under consideration, or when a subject of unusual interest was to be presented. The Franklin Institute, through its sectional meetings, has for many years adopted such a policy, but this proposed line of activity in the Engineers' Club should not in any way conflict with the activities of the Franklin Institute, as it would be confined to the technical societies, whereas, admittedly, the field of the Franklin Institute lies more along the lines of pure science of mechanic arts and of education, none of which fields would be covered by the activities of this Club. Unquestionably, much thought and effort would be required to perfect the details of such an organization, and one of the greatest difficulties to be encountered would be the preservation of the integrity of each individual organization, for no one of the several organizations, and least of all this Club, would desire to take any action by which it would lose its identity. It is, however, a recognized principle of modern times that the best results and the greatest achievements can be accomplished only through co-operation and consolidation, thus permitting of greater concentration of effort, and increasing the probability of success in its endeavors, and this Club cannot be an exception to the general rule.

I am aware that this proposition appears extremely radical, but it is recognized in all lines of endeavor that it is impossible for any individual or organization to stand still, and if attempt is made to stand still retrogression invariably results. We have always been considered, and consider ourselves, an extremely conservative organization, and while conservatism is, without doubt, a great safeguard, we should take care that our conservatism is real, and that in its last analysis it does not represent merely the inertia of indolence, or inability to grasp the requirements of modern conditions.

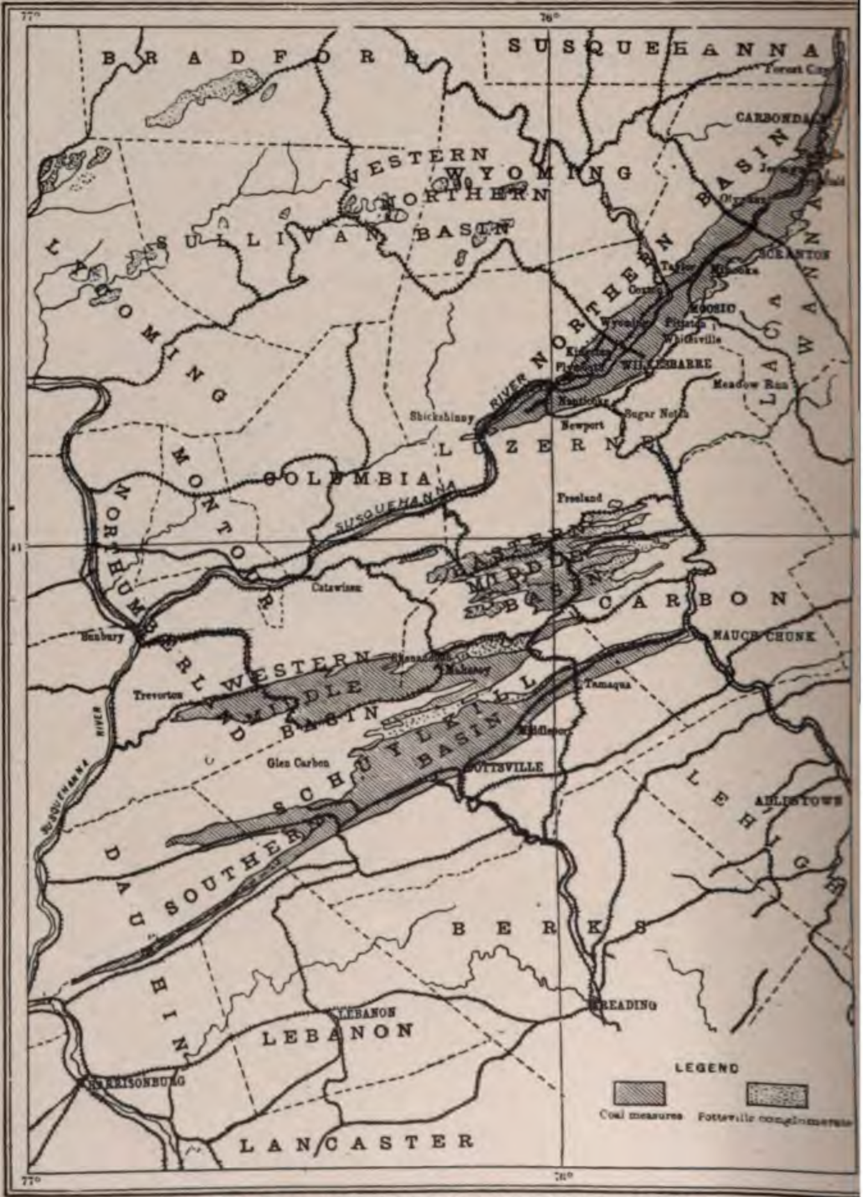
Whether or not the Club advances on this suggested line, it should, in any event, endeavor to assume a much greater activity in public affairs. When the Club was first organized, resolutions relative to public matters were continually being proposed, and in the first issue of the PROCEEDINGS of the Club are given three resolutions, one relative to the introduction of the metric system of weights and measures, second, a Memorial to Congress, requesting them to continue the appropriation to the United States Board for Testing Materials, and third, recommending to the State of Pennsylvania the enactment of laws providing for a Geodetic Survey. This activity in public affairs, which was a matter of common occurrence in the early history of the Club, has greatly decreased, until, at the present time, I believe but two resolutions relative to matters of public importance have been passed by this Club in the past five years. If this Club is to be the potent factor in the community which we desire it to become it not only should make an established practice of bringing before it all matters of public interest pertaining to engineering or technical lines, but it should go even further, and should not only discuss and pass upon existing or proposed improvements, but should initiate public endeavor and sentiment in these directions. The other non-technical organizations of the city are continually passing resolutions and initiating movements in various phases of public activity, and yet this Club, which should be the court of last resort in matters technical, rarely exerts itself to the point of interesting itself in such affairs, even when the issue is purely technical in character.

Partisan politics should, of course, never be introduced into the Club, but it is possible to participate in public affairs without consideration of politics, and this organization is failing in its purposes and shirking its obligations if it does not lend the weight of

its reputation and influence to obtaining better conditions for the community in which it has its being.

I trust you will not think that I have adopted a pessimistic attitude in regard to the condition of the Club, for this is not the case, and I believe that, no matter what course or policy of development the Club may decide to pursue, its future is assured; but, nevertheless, we should see to it, in determining these policies, that our ideals are set high, so that our endeavors will not be confined merely to the satisfaction of the individual, but that they will rise to the point where this Club will be made not only of benefit to the individual members, but of benefit to the profession at large and to the community as a whole, and that when the final chapter is read, this organization will have left its impress on the affairs of the city and state.

I wish in conclusion to express my great appreciation of the honor you have done me in electing me to serve as your President, and I also wish to thank both the members of the Club and of the Board of Governors for their hearty co-operation in all the activities of the past year.



PENNSYLVANIA ANTHRACITE COAL FIELD

Scale

10 0 10 20 Miles

After map of U. S. Geological Survey.

FIG. I.

PAPER No. 1136

THE SCRANTON MINE CAVE PROBLEM

By ELI T. CONNER

Read January 3, 1914

The anthracite region of Pennsylvania has been divided into four fields (Fig. 1)—the first being the Northern Anthracite field, extending from Forest City in Susquehanna County to Shickshinny in Luzerne County, a total length of about fifty-five miles with a maximum width of about six miles. The cities and towns which have grown up in this section with the anthracite industry were built upon the coal basin. For instance, Carbondale, Scranton, Pittston, Wilkes-Barre, and Nanticoke, are all underlaid by one or more beds of coal, so that if the problem of support of the surface is not now acute in all of these communities, it probably will be in the near future.

The second is known as the Middle Field, usually designated as the Lehigh Region. In this district the city of Hazleton is constructed in the center of the basin.

The third division is known as the Western Middle or Mahanoy Field, in which the towns of Shenandoah, Mahanoy City, Ashland, Mount Carmel, and Shamokin are located over the coal.

The fourth division, known as the Southern Anthracite Field, is the greatest basin in the region in respect of quantity of coal. It extends from the Lehigh River at Mauch Chunk almost to the Susquehanna River at Dauphin, about seventy miles in length, where the towns of Lansford, Tamaqua, Middleport, Pottsville, and Minersville, are located over the coal, so that some time or other they will all face the conditions which now exist in Scranton.

A comparison of the columnar sections in the four districts just described is shown in Fig. 2. You will note a large number of beds of coal; the thickest in the four districts is the great Mammoth bed. This bed in the Southern field is sometimes found as thick as 100 feet; in the Middle field from 10 to 50 feet, and in the Eastern Middle, there is a range from 25 to 50 feet in thickness. The columnar sections afford a very good idea of the quantity of coal.

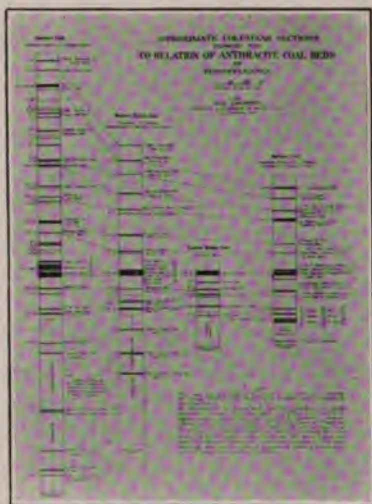


Fig. 2.

Figure 3 shows cross-sections in the Northern Coal Field, first at Carbondale, then at Scranton, the one we are particularly interested in tonight. You will observe the great number of beds and their close proximity to each other. Those are the beds that have made the trouble at Scranton.

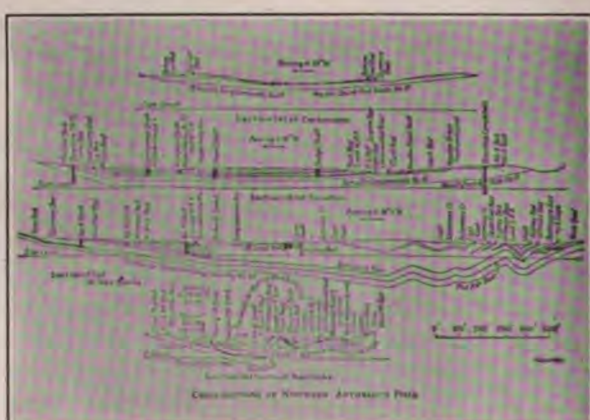


Fig. 3.

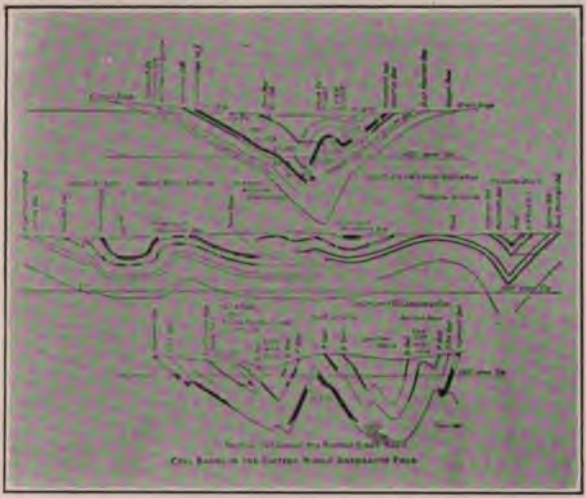


Fig. 4.

Owing to the great contortions of the measures in the Hazelton District (Fig. 4), it is very difficult to develop and mine the coal.

Cross-sections in the Western Middle Field through Mahanoy are shown in Fig. 5.

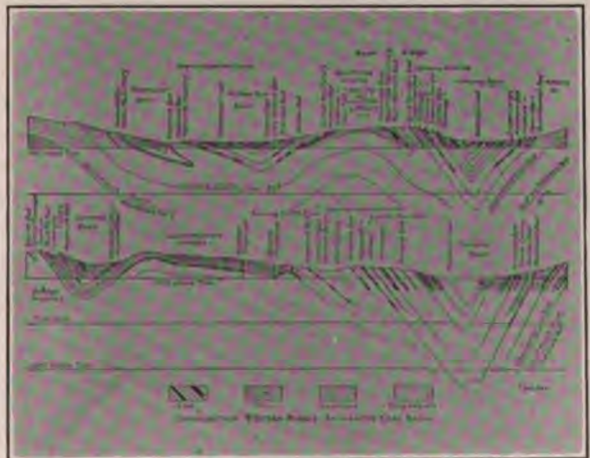


Fig. 5.

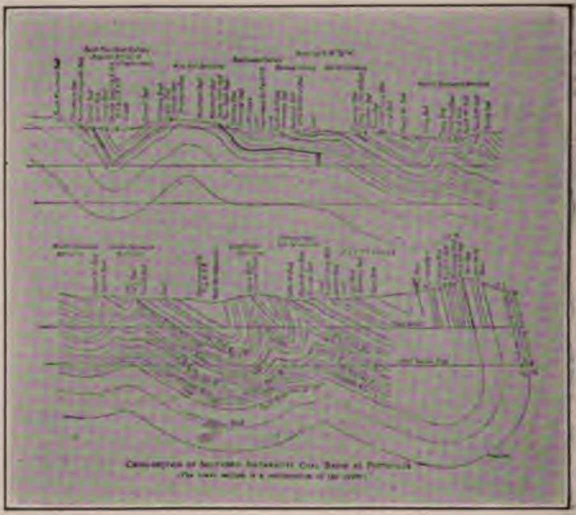


FIG. 6.

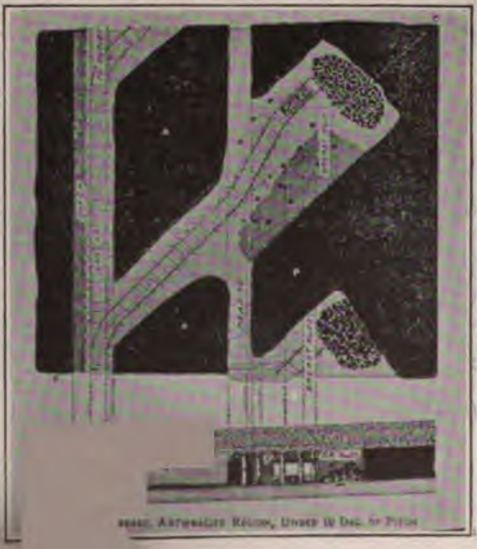


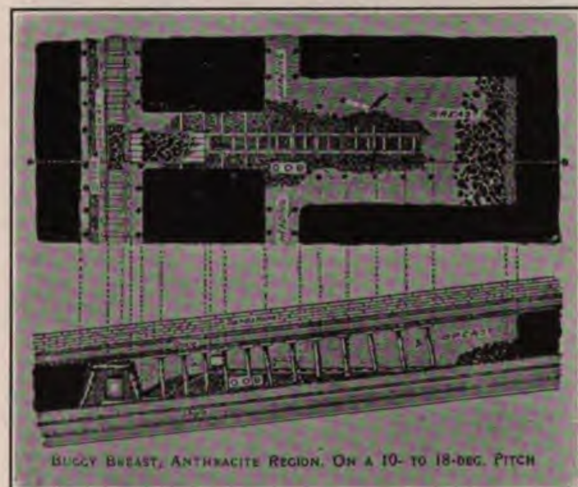
FIG. 7.

In the Pottsville District the coal dips to great depths, just how far is not known, and the illustration (Fig. 6) is largely theoretical. The deepest shaft in this section is 1,800 feet.

Where the measures run from flat up to about 10 degrees pitch the mine is developed as shown in Fig. 7.

In developing a coal mine it is necessary to drive a gangway in which is located the main road and a parallel airway.*

Figure 8 shows workings from 10° to 18° pitch. Where the grade is too steep to pull the cars up, they put in a little buggy and reload it into the main line cars from a platform on the gang-



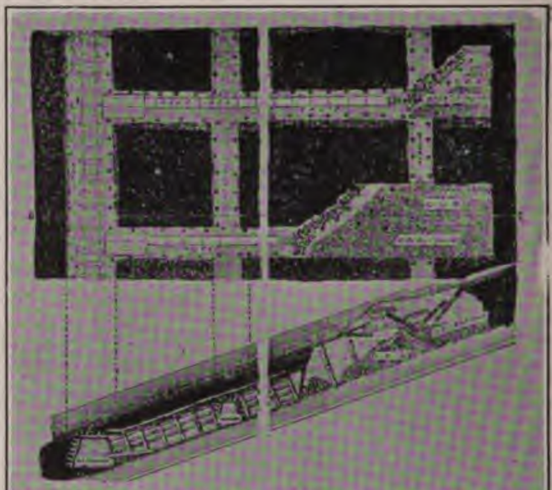
BUGGY BREAST, ANTHRACITE REGION. ON A 10- TO 18-DEG. PITCH

FIG. 8.

way. This and the cut that precedes it illustrate quite well the mining methods in the Scranton District, and in fact throughout the Northern Anthracite field. The other regions I will show are purely for comparison, as they have nothing to do with the Scranton District, or the Scranton situation.

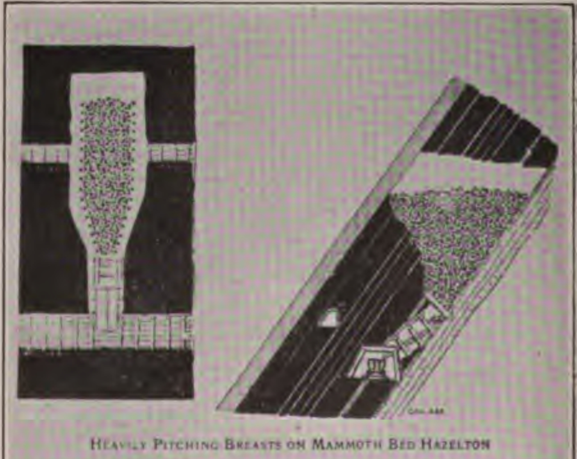
Breast mining on sheet iron, with pitches ranging from 18 to 30 is shown in Fig. 9. The chute is lined with sheet iron, upon

* These cuts, as well as the cross-section, are copied from the Second Geological Survey, Pennsylvania. The cuts were originally made by Dr. H. M. Chance, a member of this club.



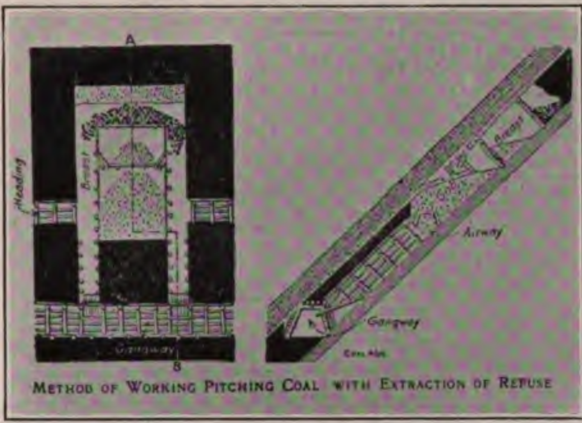
SHEET-IRON CHUTE BREAST, HAVING A PITCH OF FROM 51 TO 20 DEGREES

FIG. 9.



HEAVILY PITCHING BREASTS ON MAMMOTH BED HAZELTON

FIG. 10.

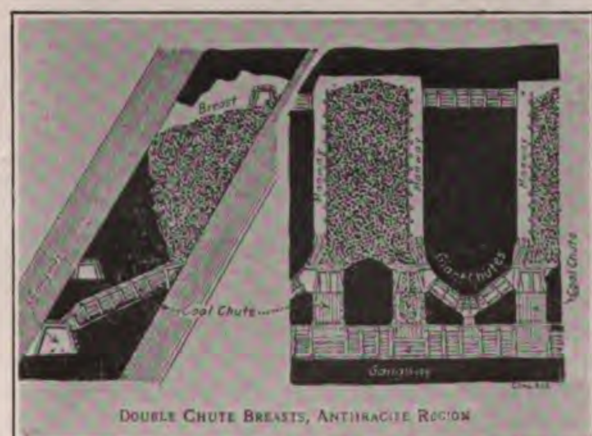


METHOD OF WORKING PITCHING COAL WITH EXTRACTION OF REFUSE

FIG. 11.

which the coal slides down to a platform where it is then loaded into a car at the gangway.

Steep pitching breasts in the Mammoth Bed in the Hazleton District. It is necessary to insert what is called a battery after the chute is driven. They usually chute up about 35 feet (Fig. 10) and put in a strong timber battery with a hole in the bottom, out of which the coal is drawn and shot into the car. The air travels



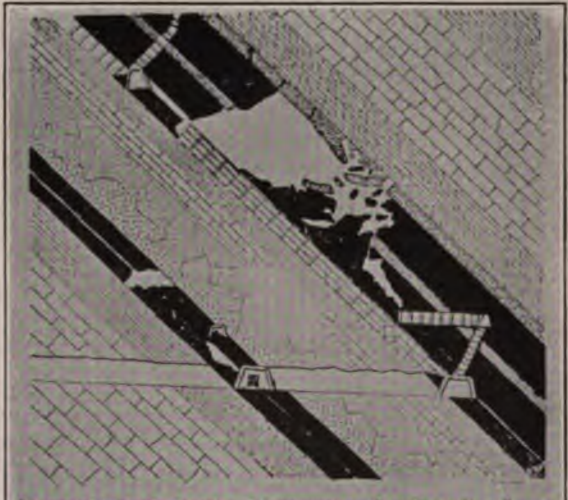
DOUBLE CHUTE BREASTS, ANTHRACITE REGION

FIG. 12.

up one side, ventilating the face and crossing over to the next breast. The man-way is about 4 feet square. The breast is always kept full of coal so that the miner can have a place to stand and do his work.

Methods similar to those just described are shown in Fig. 11, excepting that the rock refuse which is often found in the coal beds is stored in the center of the breast and the coal is drawn down the man-way, the rock being left in the breast. Sometimes there is as much as 30 or 40 per cent. of the bed refuse.

Another method of what is known as double chute mining is



METHOD OF WORKING CONTIGUOUS SEAM THROUGH HORIZONTAL ROCK T[illegible]

FIG. 13.

shown in Fig. 12. Two chutes are provided; the second chute is used to separate the rock from the coal.

Figure 13 presents another interesting picture, a method sometimes adopted in the Southern fields. It frequently occurs that in the Mammoth Bed the pressure is so great on the timbers that they cannot keep the gangways open. The weight crushes timbers as thick as 18″ or 20″. Recently, instead of driving a horizontal tunnel and maintaining a gangway in the Mammoth Bed, they drive the rock chutes up at an angle from the gangway in underlying bed and draw the coal down as shown in the pictures preceding this.

Fig. 14.

From the Figures that have just been shown, some idea of the method of attack and recovery of coal can be formed.

The city of Scranton, covering about 10,000 acres (Fig. 14), is nearly all underlaid by coal.

Figure 15. Showing part of mine workings at Scranton; a portion of the Geological Map of the City (the Second Geological

Fig. 15.

Survey of the State of Pennsylvania). I have introduced this to try to illustrate the difficulties that have occurred. The heavily shaded portion of the map is a section where at the time the survey was made, in 1885, six beds of coal had been partly worked. The survey maps show all of these six beds in colors, and this is a photograph of that map. It illustrates to some extent the cause of the present trouble. The lightly shaded portion is where but one bed, apparently, has been worked.

Mining has been in progress under the present city limits for about seventy-two years, and during that time there have been many instances where caves occurred in the mine workings affecting the surface more or less seriously. The community and mining men made light of the danger; from this indifference, however, the city was rudely awakened to the gravity of the situation in the summer of 1909, when a cave occurred on the West Side, known as Hyde Park, that affected an area of two or three acres of the surface and almost completely destroyed a school house known as No. 16. Fortunately, the school building was not occupied when this sudden collapse occurred, but the possibilties of danger, had the usual number of pupils and teachers been in the building, aroused in the minds of the people much concern as to the safety of other portions of the city. At a general meeting of the Board of School Control, the City Council, and the Board of Trade, the subject was fully discussed, and the danger to the other portions of the city considered. After much deliberation, it was suggested that, in order to correctly inform the authorities and the public, it was desirable to have the actual mining conditions investigated by disinterested engineers. The suggestion was made by former Mayor J. Benj. Dimmick, that an advisory board of disinterested engineers be appointed, who had no interest in Scranton affairs or with local corporations, to serve without compensation. This Board was first composed of John Hays Hammond, W. A. Lathrop, D. W. Brunton, R. A. F. Penrose, and L. B. Stilwell. It was afterwards increased by the addition of Dr. J. A. Holmes, Director of the Bureau of Mines, and Dr. H. S. Drinker, President of Lehigh University, and later by the appointment of Professors J. F. Kemp, of Columbia, J. F. McClelland, of Yale, and H. L. Smyth, of Harvard. They suggested that the authorities employ engineers to investigate the conditions and make a report, and recommended William Griffith, of Scranton, and

myself. We began work in October, 1912, and in the course of the investigation, we took numerous photographs of conditions observed in the mines, which will be shown by cuts following.

Figure 16 is a portion of an ordinary mine map, showing the distribution of pillars, openings, etc. You will note that about one-third of the coal has been left in the form of pillars to support the roof. This old rule of leaving one-third of the coal has been quite generally followed; in fact, it has been too generally followed. We observed instances in our inspection where considerably less than one-third of the coal had been left in the form of pillars. Generally speaking, 33 1-3 per cent. of the coal left in pillars,

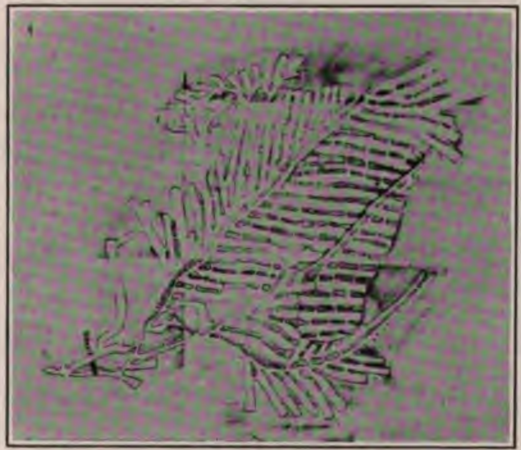


Fig. 16.

properly distributed, is enough to carry the overburden up to a depth of 250 feet, and under such conditions it is unlikely that any serious caves would have occurred, but as has been shown on the cross-sections, and will be shown on plates to follow, there are in the main part of the mine workings, five separate beds of coal, aggregating in thickness about 45′ in a total interval of about 160′. These five beds are the best found in that region, and were the earliest attacked, particularly the Diamond and the Big, or 14′ Bed.

In the early mining, no attempt was made to columnize pillars, consequently there are many instances of pillars in an upper bed

standing over openings in the bed immediately below, oftentimes when the intervening strata is as thin as 10 feet. This condition naturally causes great complexity of strains on the intervening strata and on the overburden. This irregularity of pillars is illustrated by Figure 17, which represents four beds of coal. Note the pillar over the opening, all of the overburden naturally resting on the first bed of coal. A slight disturbance of any kind may cause the pillars to crush through into the openings below quite like a conductor's punch.

It was found in the investigation of No. 16 School, that pillars in the beds of coal which collapsed were not columnized, and it was suggested that perhaps some slight disturbance, as the min-

FIG. 17.

ing of bottom bench coal in Diamond bed, caused some shaking of the strata, the pillars in the upper beds crushing through into the openings of the lower.

In order to illustrate the report, we thought it quite necessary that maps should be incorporated, showing the worked-over areas. For this purpose, we used the city atlas, containing 24 plates, which we traced, showing the principal streets, alleys, avenues, principal buildings, etc., such as churches, the post office, school houses and other structures. Figure 18 indicates the method of designating the several beds of coal. In this vicinity, there are eleven beds on the west side, the cross-section showing them better than anything else. The principal coal beds are the Dia-

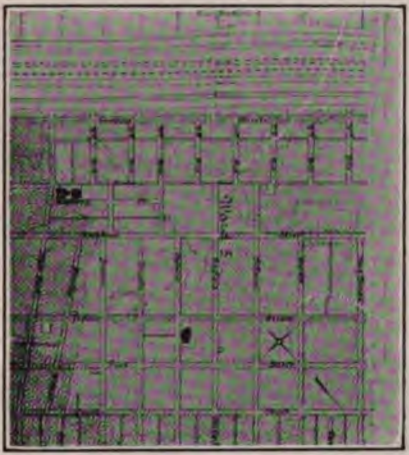


Fig. 18.

mond, 14′, New County, and Clark. The four beds in the center of the series, which, as I have before said, aggregate sometimes 45 feet in thickness in a total of 160 feet of strata, are the ones that have caused the trouble, and will in the future. A property owner through these maps can determine whether they have been working under his property, the beds worked, and their thickness

Fig. 19.

and other details, but he cannot find out how many pillars there are under his land. The corporations were very courteous, but they would not consent to our showing the individual pillars, and it would have been impossible, even had we tried.

Figure 19 is another of the maps, showing part of the East Side where the most important buildings have been erected. The white area shows where the owner has not sold his coal. That constitutes a large pillar. The Central High School is shown. The Big Bed, about 14 ft. thick, is mined under part of the building. The cross-section shows the Big Bed partly mined very close to the surface. While some of the openings have been slightly

Fig. 20.

caved, no material damage has been done, but if there should be a serious squeeze in the Clark Bed beneath, there is no doubt but that the Big Bed above would collapse and seriously injure the part of the City under which it has been mined. It will be noted that there are not nearly as many workable beds on the East Side of the river as on the West.

In reading about coal mining, you often see the statement that the pillars have been "chipping." To one who is not familiar with these conditions, this is unintelligible. We took several photographs of "chipping" pillars, and the one shown in Fig. 20 is a good illustration. This picture was taken not far from the Central

High School, in the Clark Bed, which at this point is between 6 and 9 ft. thick. In most beds of coal there is one bench or layer which is softer than other portions of the bed. In the case of the Clark Bed, it is very near the center. Where you see the note-book placed, is a large sliver of coal. This coal has fallen off the pillar, due to the pressure—slow, imperceptible, but most thorough in its pulverizing action on the coal, which may continue for a long time before the roof breaks, or before there is a general collapse; but after a while, the chipping is a sure indication that later on the pillars will be completely disintegrated and the whole over-burden settle down, unless remedial measures are applied.

Fig. 21.

Figure 21. This picture was taken on the corner of the solid pillar under No. 25 School House. At that point, it was about 700 feet below the surface. The Dunmore Bed, as found there, is 4.5 feet thick. The usual rule of leaving one-third of the coal in the form of pillars was followed here 700 feet below the surface. This was a great mistake, as it was insufficient to support the over-burden, consequently a creep was started, and it is gradually, but surely, crushing all the pillars and affecting the surface. A short time after our inspection, the opening where this picture was taken was closed, and inaccessible. While this creep in the Dunmore

Fig. 22.

Fig. 23.

Bed has, as I have said, affected the surface to some extent, it is not enough to cause any particular alarm, excepting at No. 25 School House. One-half of this building was erected on a lot where the School Board owned all the coal beneath, while the other half of the building is on a lot beneath which the coal has been partly mined. The building is of brick, and the gradual subsidence, due to the creep in the Dunmore Bed, pulled one-half of the building down to some extent. The total subsidence apparent on the surface was about eighteen inches. The opening where the man shown in the picture stands was completely closed shortly after we were there.

Figure 22. This is a picture of the four foot Bed, directly beneath School No. 25, 500 feet above the Dunmore Bed. The peculiarity about this is that the settling of all of the strata from the surface down to the Dunmore Bed, 700 feet deep, did not apparently affect the workings in this 4 foot bed. This is an instance of working a bed only about 3½ feet thick. The upper portion is refuse, 2½ to 3 feet of rock, that must be blasted, and disposed of, which makes rather expensive mining

You will sometimes hear the expression "local falls." Fig. 23 is a picture taken to show local roof falls. There is a prop sticking up through the fallen material that indicates about where the top of the opening formerly was; and above that is the space from which the roof material has fallen.

In the early days of mining, it was customary to take only the best beds and the best portions of those beds. In the case of the Diamond Bed, which was the earliest mined in the Scranton District, there is a bottom bench varying in thickness from 4 to 6 feet, which was formerly not considered minable; therefore it was left, and in recent years, large portions of the old workings have been re-opened, and much coal recovered. In recovering this bottom bench coal the original coal pillars are not disturbed, but as the height of the pillars is increased by the removal of the bottom coal, they are also weakened.

After describing the conditions observed, we will show the various methods heretofore adopted for supporting the roof. The picture shown represents the ordinary cog or crib support which is very effective when properly installed, for a few years until the timber rots. In the particular instance shown on Figure 24, we were informed that these cogs with others nearby stopped a creep or squeeze which threatened to destroy the Main Slope.

FIG. 24.

Figure 25. Represents a wall, or pier, or pillar, erected in th
Clark bed, under the Central High School. It has the appearanc
of being substantial, but when a hole had been broken through i
(Fig. 26), to conduct a flush pipe to another part of the mine, i

FIG. 25.

FIG. 26.

FIG. 27.

was found to be principally loose gob. It may be called a "delusion and a snare," as far as supporting strength is concerned. I doubt whether engineers would consider this a good support for a building of any weight.

Many owners of residential property and valuable surface rights, fearing the probability of subsidence which would injure their improvements, employed men to construct "gob pillars" under their properties. Fig. 26 represents one of these pillars; it is merely ordinary mine rock partly filled in with small stuff that can be thrown in with a shovel. In many instances, these so-called pillars are not even chinked up tight to the roof. They are quite expensive to construct.

Figure 27 shows a picture of a sand-stone cement laid pillar, under one of the school houses. In this instance, they had spaced off 16 pillars such as that shown, making a very effective support.

Having shown the several methods of supporting the overburden, heretofore adopted, we are of the opinion that, speaking broadly, none of the so-called supports are trustworthy. This is particularly the case with reference to the dry wall gob pillars, of which type many have been constructed at large expense. This will be more particularly referred to further along.

The system of flushing mines with refuse was somewhat incidental at first. As near as we have been able to learn, the first instance of the adoption of this system was at the Laurel Hill mine, of the A. Pardee Company, at Hazleton, in 1885, where a creep started near the Main Slope in the Mammoth Bed, and it was found impossible to stop it by the ordinary methods of timbering. It then occurred to the management that if the openings could be filled with refuse material, well packed in, the difficulty might be overcome and the destruction of the Main Slope prevented. They, therefore, arranged to discharge the culm refuse from the breaker, into these openings, conducting it through pipes with sufficient water to carry it along. From this beginning has grown a system of disposal of refuse at the mines, and effectively supporting the roof where the material is properly deposited. The procedure is to brattice off with plank the mouths or lower end of a series of breasts or chambers, and to discharge the water and culm (Fig. 29) into the upper end of the series of breasts, the material then flowing into the several openings, precipitating the solid matter and the water seeping away through the plank brat-

Fig. 28.

Fig. 29.

Fig. 30.

tices and flowing to the pumps. This flushed in material, which composed of small particles of coal and pulverized slate, packs ve solidly.

I may explain that culm is small coal—too small to be markete

Fig. 31.

Figure 30 shows a gangway reopened through an area that has been flushed full. The wall or rib on the right is culm. You will notice it stands almost as straight and nearly as solid as the coal pillar.

Figure 31 is a picture taken in the same gangway as that just referred to. In this instance, it was not properly deposited, as you will see a space of about 18″ on top where the Fire Boss is lying. The point I want to make in showing these pictures is that the material washed in in that manner packs quite solidly.

Figure 32 is shown to give an idea of what might be called good

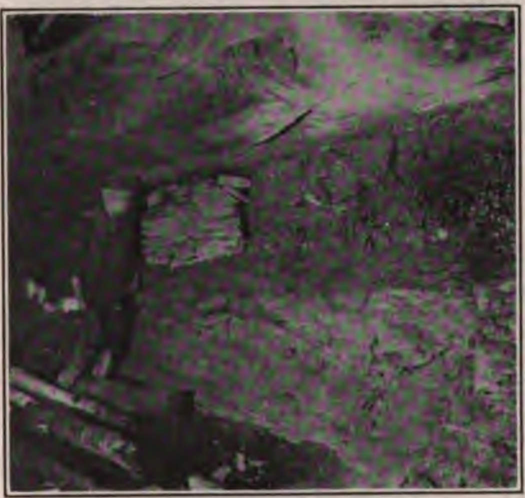


Fig. 32.

conservation. There is a bed of coal only 20 inches thick, and from the bottom of the bed down to where the road is, is about 4 feet of rock. The rock was taken out from here and transported to another bed nearby, and compactly walled in, so that the pillars could be removed and the overburden settle down with very little effect on the surface. The distance from the top of the coal to the surface was not very great, so that the weight was comparatively light.

After completing the investigation of the mine workings of 27 collieries within the city limits, which required over 40 days of underground tramping, and after considering the various methods

Fig. 33.

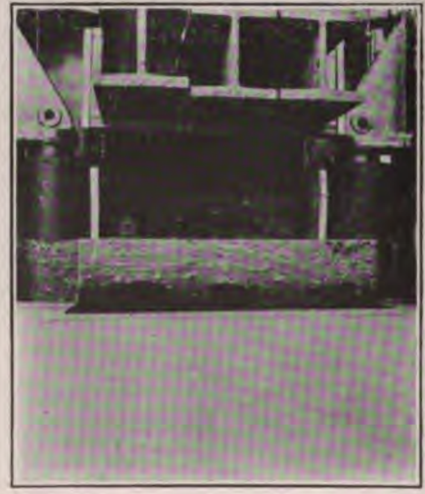


Fig. 34.

of support that heretofore had been adopted, and those that have been suggested, we were of the opinion that a large amount of money had been wasted on inefficient devices for the protection of valuable surface improvements. We, however, hesitated about condemning these devices without having some authoritative information relative to the supporting value thereof. As there was no reliable data obtainable on this subject, we determined to make some tests which we hoped might throw some light on the subject, and might point the way to more effective devices. For this purpose, we shipped, from one of the mines at Scranton, to the Fritz Engineering Laboratory, at Lehigh University, a carload of mater-

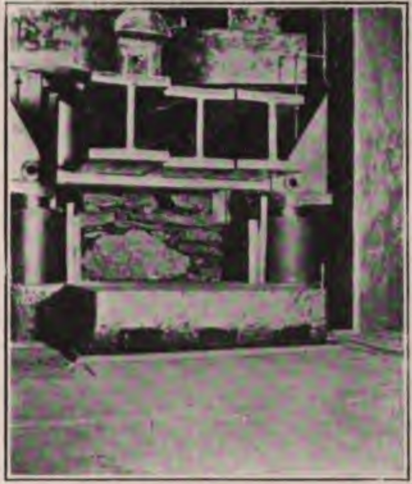


FIG. 35.

ial of exactly the kind used in the mines for roof support. Fig. 33 shows a timber crib chinked in with mine rock as near like cogs erected in the mines as possible. This picture was taken before the pressure was put on.

Figure 34. Shows the same crib after being subjected to 900,000 pounds pressure—almost the limit of the testing machine. The maximum settlement was 7.5″. I will show tables a little later that give the effect.

Figure 35. Shows a gob pillar made up in about the same manner as was customary under the City of Scranton.

Fig. 36.

Fig. 37.

Figure 36. Shows the same pillar after having been subjected to 489,150 pounds pressure, from which it will be noted that as an effective support, it is practically worthless.

That pillar was about 5′ long, 2′ 4″ wide, and 18 high. In this case, it showed at the collapse, 5.3″ compression.

We procured a cast iron cylinder of considerable strength and measured dimensions, filled it with culm flushed in in the same manner that it is flushed into the mines; then we put it over the boilers and dried it for a couple of days—though it was not completely dried—and then subjected it to pressure (Fig. 37). The results will be shown on the tables to follow. We used the same cylinder in testing dry and wet sand, broken stone of about 1½″ in size, and then broken stone with the voids filled in with sand and small stone, and various other tests were made which are shown on the tables to follow:

Fig. 37.

STATISTICAL TABLE OF COAL MINING.

Coal beds.	Average thickness of beds.	Original area before mining.	Area mined over.	Area to be mined.	Approximate area of pillars.	Area of mine excavation.	Foot-acres mined over, including pillars.	Foot-acres excavated, excluding for pillars.	Foot-acres to be excavated, leaving one-third for pillars.
	Feet.	*Acres.*	*Acres.*	*Acres.*	*Acres.*	*Acres.*			
Eight-foot	7.6	140	111	29	35	76	843	577	146
Five-foot	4.4	2,000	1,093	907	364	729	4,809	3,208	2,660
Four-foot	3.6	2,460	994	1,466	331	663	3,578	2,387	3,518
Diamond	9.4	4,160	3,562	598	1,187	2,375	33,495	22,325	3,746
Rock	5.2	4,500	3,000	1,500	1,000	2,000	15,600	10,400	5,200
Big	12.2	6,000	4,831	1,169	1,610	3,231	58,938	39,296	9,508
New County	6.0	5,360	1,549	3,811	516	1,033	9,294	6,198	15,244
Clark	6.7	7,860	6,040	1,820	2,013	4,027	40,468	26,981	8,130
Dunmore No. 1	3.0	7,500	690	6,810	230	460	2,070	1,380	13,620
Dunmore No. 2	4.0	9,630	2,533	7,097	844	1,689	10,132	6,756	14,194
Dunmore No. 3	3.3	8,500	1,573	6,927	524	1,049	5,191	3,462	15,240
	....	58,110	25,976	32,134	8,654	17,322	184,418	122,970	91,206

Total space excavated in the mines under Scranton	cubic yards	198,104,670
Total estimated excavation for Panama Canal	cubic yards	174,666,594
Total approximate tonnage of coal produced to January 1, 1911	long tons	176,840,000
Total approximate tonnage of coal waste and mine refuse excavated, but not included in production	long tons	44,500,000
Average production per foot-acre excavated	long tons	1,440
Average production per foot-acre mined over	long tons	960
Number of collieries and mines operating under the city		27

We made the comparison of the excavation under the City of Scranton and the excavation made on the Panama Canal as offer-

ing the most striking illustration we could think of. The Panan
Canal excavation has probably been somewhat increased by t
slides since this report was made. It must not be supposed th
all of that space is open, because, as I have described before, ma
caves have occurred that have completely closed the old openin
so that in all probability there is not more than 50% of the sp
now standing open.

Figure 38. Table No. 4. This table gives the result of
tests. The first column describes the various tests that were ma
"Table No. 4." I think the reading of it will be more impress

Supporting Strength of Various Forms of Dry Fillin

Kind of material comprising the artificial supports.	Approximate depth, in feet, of column of coal measure rock 1 foot square, necessary to compress artificial roof supports—						Remarks
Per cent. of compression	1	3	5	10	20	30	
	Feet.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	
1. Rectangular gob piers, ordinary construction	......	10	12	36	125	306	Free to exp laterally
2. Circular piers of mine rock, well constructed	......	46	75	146	292	512	
3. Timber cogs filled with gob, average construction	......	8	68	182	270	419	
4. Loose pile of broken sandstone through 1¾-inch ring, 40 per cent voids	......	......	20	53	124	298	
5. Pile broken sandstone, 40 per cent voids, voids filled with sand	......	......	21	53	186	465	
6. Loose pile large size broken sand rock, 45 per cent. voids	......	48	66	121	351	492	
7. Mine room filled with large broken sand rock, 50 per cent. voids	12	27	45	117	434	[1]615	
8. Mine room filled with broken sandstone, 40 per cent. voids	......	44	74	177	619	1,310	
9. Mine room filled with broken sandstone, 40 per cent. voids, filled with sand	......	46	77	325	6,000	[2]6,660	
10. Mine chamber filled with dry coal ashes, 64 per cent. voids	......	13	25	70	143	332	
11. Mine room filled with dry river sand	12	40	70	442	1,715	6,640	
12. Mine room filled with river sand flushed in with water	111	522	891	2,310	......	[3]8,860	
13. Mine chamber filled with coal culm flushed in with water	32	118	190	472	1,822	5,905	
14. Concrete pier, 1 part cement, 7 parts sand and gravel; 5 months old	117	1,092	Gradually cracked to pieces under continuous load equal to 600 feet of rock.				
Resistance of flushed culm	1	1	1	1	1	......	Comparat
Resistance of flushed sand	3.5	4.4	4.7	5	4	......	
Concrete pier	3.6	9	[4]	[4]	[4]	[4]	

[1] 27 per cent. settlement.
[2] 23 per cent. settlement.
[3] 20¾ per cent. settlement.
[4] Worthless.

Fig. 38.

Results of Tests of Compressive Strength of Various Forms of Roof Support.

No. of test.	Construction tested.	Net tons per square foot required to produce compression of— 1 per cent.	3 per cent.	5 per cent.	10 per cent.	20 per cent.	30 per cent.	Compression and load (tons per square foot) at end of test.	Remarks.
1	Rectangular piers of mine rock	....	0.8	1.4	2.7	9.5	23	....	Average construction; voids not filled.
2	Circular pier of mine rock	....	3.5	5.67	11	22	38.5	Compression, 31 per cent; load, 42.5.	Well constructed; voids filled with small and shovel stuff.
3	Timber crib filled with mine rock	....	.6	1.37	5.11	20.3	31.5	....	Average construction.
4	Pile of broken sandstone; small pieces	....	....	....	4	9.3	22.4	Compression, 46 per cent; load, 104.5.	
5	Pile of small-size broken sandstone and sand.	....	....	1.6	4	13.5	35	Compression, 45 per cent; load, 144.	
6	Pile of broken sandstone; large pieces	....	3.6	5	9.1	26.4	37	Compression, 41 per cent; load, 75.	In these tests the material was not confined, but was free to expand laterally.
7	Pile of coal-measures sandstone similar to No. 6.	0.8	2.1	3.5	9	33.4	....	Compression, 27 per cent; load, 56.	
8	Pile of river sand	....	....	....	....	....	....	Compression, 63 per cent; load, 108.	
9	Broken sandstone in cylinder	....	3.33	5.55	13.32	46.6	98.6	Compression, 35 per cent; load, 666.	
10	Broken sandstone and sand in cylinder	....	3.5	5.77	24.42	308.5	....	Compression, 23 per cent; load, 686.	
11	{ Dry coal ashes in cylinder	....	1	1.86	5.32	10.8	25	{ Compression, 51 per cent; load, 666.	In these tests the material was confined and could not expand laterally.
	{ Coal ashes flushed in with water	....	....	....	....	5.5	22		
12	Wet culm flushed in cylinder; partly dried (average of two tests).	2.44	8.9	14.28	35.52	138.7	444	Compression, 33 per cent; load, 668.	
13	Dry sand in cylinder	.88	3	5.27	33.3	129	499	Compression, 32.2 per cent; load, 666.	
14	West sand flushed in and partly dried	8.4	39.3	67	173.8	555.4	....	Compression, 20.75 per cent; load, 666.	
15	Concrete made of cement, sand, and gravel; 4 months old; 1 barrel Portland cement to each cubic yard of concrete (about one part cement to seven parts sand and gravel); piers 3 inches by 2.81 inches by 3.85 inches high.	9 Cracked.	84	Gradually crushed to pieces under continuous load of 45 tons.					This test was made at the Dickson Works of the Allis-Chalmers Co. in Scranton, by William Griffith.

Fig. 39.

than what I can say, although I will explain what the percentage figures on the top mean. From the bearing strength of the several types of supporting devices which we tested, we calculated the amount of subsidence that would result in each instance. The note on top explains what that was. The 10% means that proportion of the open space. If there is an opening 10 feet high, there would be in this case 10% of subsidence of the roof. Sand is the strongest material. A mine room filled with broken sandstone with about 40% voids would only sustain 177 feet of overburden for 10% subsidence. The same filled with broken stone, 40% voids filled with sand, would carry 325 feet for 10% subsidence. I refer particularly to 10% because we believed that was the limit that should be allowed.

The idea of testing the sand was to show the relative values of the various materials that might be used for filling the openings

HORIZONTAL AREA, IN SQUARE YARDS, OF ARTIFICIAL MINE PILLARS OF CONFINED FLUSHED CULM OR FLUSHED SAND REQUIRED UNDER VARIOUS PERMISSIBLE COMPRESSIONS TO SUSTAIN ONE-THIRD OF THE OVERBURDEN OF ONE CITY BLOCK OF FIVE ACRES, AT VARIOUS DEPTHS.

Ultimate uniform compression permitted.	Depths.					
	25 feet.		50 feet.		100 feet.	
	Culm.	Sand.	Culm.	Sand.	Culm.	Sand.
Per cent.						
3	3,424	800	6,848	1,600	13,696	5,200
5	2,122	452	4,244	904	8,488	1,808
10	848	176	1,696	352	3,392	704
	200 feet.		400 feet.		800 feet.	
3	(1)	6,400	(1)	12,800	(1)	(1)
5	16,976	3,616	(1)	7,232	(1)	14,464
10	6,784	1,408	13,568	2,816	(1)	5,632

[1] Openings filled.

NOTES.—1. Up to 3 per cent. compression, piers of sand and gravel concrete might be only one-half the size of sand piers, but for weights that would produce greater compression they are worthless.

2. One city block of 5 acres covers 24,200 square yards.

3. In fixing upon the amount of compression that might be permitted, consideration should be given to the fact that where several beds are to be filled the total settlement will be several times as great as for one bed of the average thickness.

4. It will be noted that complete filling with culm is necessary for the compression mentioned at depths of 200 to about 500 feet, whereas for greater depths the compression due to the greater weight would be excessive. Sand, on account of its greater strength, is suitable for filling all beds at all depths under the city of Scranton, and is, therefore to be preferred.

FIG. 40.

and the tests show very conclusively the limitations of the culm filling. We found it would not be suitable for depths much over 500 feet. If we went over that, the culm would compress so greatly that it would not give what we would deem a safe allowance for the subsidence of the surface.

Figure 39. Table No. 3. This table shows the comparative value of the several supporting devices I have described, and of the materials tested to determine their strength.

It will be noted that sand deposited "by flushing" method is the best.

Figure 40. Table No. 5. 3% subsidence is so very little that it would be almost useless to use it. We assume that the surface would not be seriously injured with 10% subsidence. I might explain that in working out these results from our tests, we had in mind the probable future recovery of the remaining pillar coal, because some time or other it must be taken out. At present the coal companies are leaving the pillars in, but they have the undoubted right to remove them, and we worked out these calculations with a view to perhaps recovering some of that pillar coal, and the consequent subsidence of the overburden would, we thought, have to be limited to not over 10%.

Approximate Cost per Foot of Coal-Bed Thickness of Artificial Mine Pillar of Confined Flushed Culm or Flushed Sand Required under Various Permissible Compressions to Sustain One-Third of the Overburden of one City Block of Five Acres, at Various Depths.

Ultimate uniform compression permitted.	Cost.					
	Depth, 25 feet.		Depth, 50 feet.		Depth, 100 feet.	
	Culm.	Sand.	Culm.	Sand.	Culm.	Sand.
Per cent.						
3	$286	$266	$572	$532	$1,144	$1,064
5	176	150	352	300	704	600
10	70	60	140	120	280	240
	Depth, 200 feet.		Depth, 400 feet.		Depth, 800 feet.	
3	[1]$2,016	$2,128	[1]	$4,256	[1]	[1]$8,070
5	1,408	1,200	[1]	2,400	[1]	4,300
10	560	480	$1,120	960	[1]	1,920

[1] Filled.

Fig. 41.

Figure 41. Table No. 6. I wish to explain that we use a factor of safety of 2. We believed that the cost of putting in these pillars would be much less than the estimates shown on Table No. 6.

The practical deduction from these tests is that the only effective method of supporting the roof, generally applicable, is the flushing or silting system, which, if properly done, will permit of the recovery of nearly all of the pillar coal remaining—the best kind of conservation.

An instance of this is the experience of the City of Essen, Germany, the home of the great Krupp works. Eleven beds of coal underlie the city, that were mined years ago by the room and pillar method, and abandoned without recovery of the pillar coal, probably 50% of the original content. After the German engineers had investigated the flushing system in the anthracite region of Pennsylvania, they adopted it at Essen, using for filling material crushed slag and refuse from the Krupp works. By this means, they are now recovering practically all the pillar coal. Their experience is that the overburden settles so gradually and uniformly that the surface improvements are very little damaged.

Since our report was filed, the mine cave problem has been exhaustively investigated by a commission of eminent mining men and representative citizens of the anthracite region, under appointment of Governor Tener. The Chairman of the Commission was Mr. W. J. Richards, Vice President and General Manager, P. & R. C. & I. Co.

The most important feature of this report was the formal offer of the large anthracite mining companies to the communities affected by mine caves to bear about half the cost of surface damages, or to sell to the surface owner the pillar coal under his property at about the going rate of royalty. The communities interested voted on this proposition and rejected it. As is well known, the mining companies have the legal right to remove all of the coal without liability to the surface owners for damages by reason of mine caves. The action of the large companies in making the offer mentioned is an admission of at least a moral responsibility. Some of the companies are now repairing damages to dwelling houses, etc., caused by caves.

The last legislature passed laws giving to municipal authorities in the anthracite region certain regulatory powers over mining,

particularly with relation to the support of streets and alleys. These laws are rather drastic, and are being resisted by the companies as unconstitutional. The suits will, doubtless, take the long, slow course through the courts to determine whether or not the laws are enforceable. Meantime, mining continues at the rate of about 6,000,000 tons per year, and the damage to some parts of the city grows.

As I explained, the recent laws are disputed at present. Under that law the State is given the right to the maps. The State authorities through their Mine Cave Commission demonstrated that the maps furnished them were not the latest revised maps, and as a consequence, some of the officials of the coal companies were arrested—officials of the Delaware and Hudson Company and also of the Delaware, Lackawanna and Western. They were each fined a thousand dollars or had the option of spending three months in jail. They of course appealed from the decision and the case will now have to go through the courts. What you said before was relative to the industry bearing the burden. I think that is pretty nearly the way the thing will finally land, although, as I said before, the coal companies have by their action relative to paying part of the damages admitted at least a moral responsibility, and when it is finally decided as to the division of the burden, it is probable that the coal companies will be compelled to take part in it. The legal penalties, etc., also come in, and the general public has to share in it in the price of coal.

PAPER No. 1137

THE DEVELOPMENT OF THE MODERN ELECTRICITY SUPPLY STATION

By I. E. MOULTROP AND W. N. SMITH

Delivered Before the Joint Meeting of the A. S. M. E. and the Engineers' Club of Philadelphia

March 14, 1914

In presenting a review of present day engineering practice in large central stations it has seemed well to first state the broad underlying considerations which are common to all stations, and then present some views of a number of stations, which will indicate both the effect of local conditions and the advances in the art.

With a few notable exceptions where very large water powers are available, most large cities and their neighboring suburbs are of necessity served with power obtained from coal. The great development of steam operated central stations during the past twenty years has been due primarily to the growing service requirements of our great metropolitan communities, which are situated without regard to coal supply or water power. Their rapidly growing demand for service has been greatly augmented by the improved lamps and the wonderful development of all kinds of electrically operated machinery and appliances. The development of the steam turbine, and further refinements in the use of steam during this period, have lowered both the operating expenses and the fixed charges of the central station; and altogether a great reduction in the cost of electrical energy has been made possible.

This reduction in cost of electric energy in Chicago has been effected very largely by the gradually increasing ability to generate current in large quantities and transmit it at high pressure to the more or less remote suburbs.

Figs. 2 and 3 illustrates the rate of growth of two large systems. While the great reduction in cost has been made

possible partly by this large increase in the quantity produced, cheap generation and cheap transmission at high pressure have been the large factors in this reduction. The engineering features

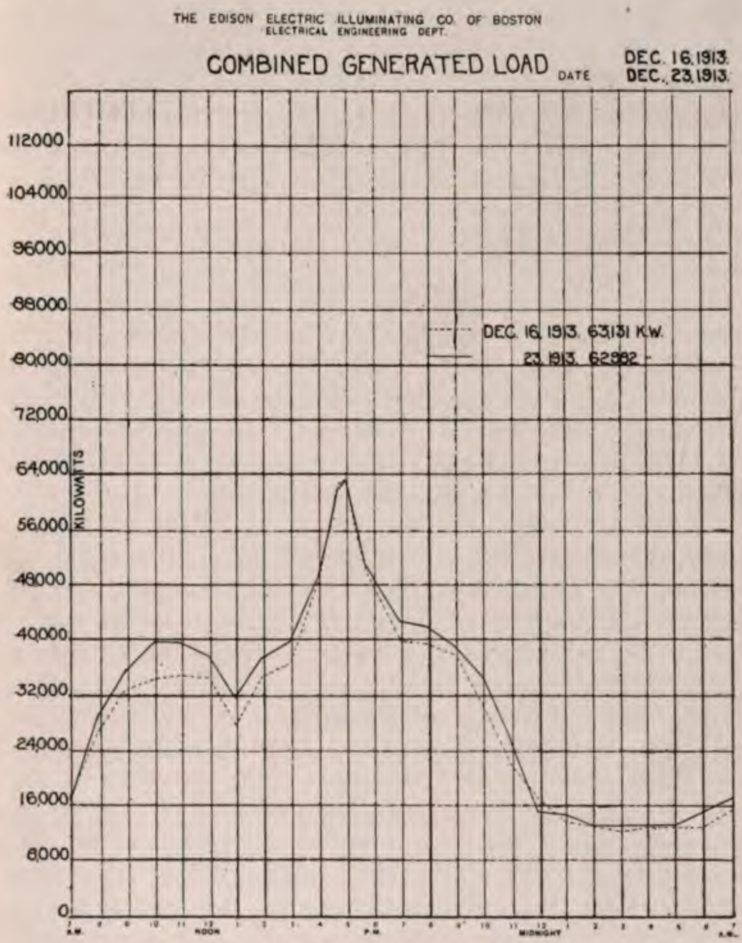


FIG. 1.—Typical Load Curve, Boston Edison Co.

that have brought about this diminished cost of power production in large quantities will now receive our attention.

There are three great conditions to be met by any public utility plant, namely, capacity, reliability, and economy. Central Station

Engineering now fully recognizes the first two conditions as well as the third. Electric service now touches the community at so many points that from a luxury it has become a necessity. It ranks next in importance to the aqueduct, the highway, and the steam railroad, and alongside or even ahead of the gas plant, as a public utility. The managers of corporations rendering public service have long since passed the stage where they are willing to take chances of breakdowns rather than spend money for improvements; and the efforts of public utility engineers are now being directed towards keeping ahead of the requirements, rather than to stay as far behind as they dare.

Capacity and reliability equally require the expenditure of large sums of money to give the public the quality of service it has a right to expect. Economy dictates the rendering of that service at the lowest possible cost. Capacity dictates the size of the plant and its units. Reliability calls for substantial and proper design, and in connection with economy, settles the location of the plant. Economy also prompts the adoption of refinements in the construction and use of the equipment to the end that it shall give both the best quantity and quality of service for the least aggregate annual expense.

Most electric service systems have been started from beginnings like that of the Head Place Station in Boston in 1886, a small non-condensing station, in the center of the business district. In 1891 a station was built at tide water on Atlantic Ave. of 4,000 K. W. capacity, to which a 6,400 K. W. extension was added in 1898. This was all DIRECT current, for distribution at low pressure throughout a relatively small business section of the City of Boston.

The development of the alternating current system of power transmission and distribution began about 20 years ago. This brought into use higher transmission voltages and soon made it possible to locate the generating station for the system, at a place where coal could be cheaply transported, handled, and stored, and where a continuous supply of condensing water would make possible the minimum consumption of fuel.

About the first of the large stations to be so located was the Brooklyn Edison Station, built at Bay Ridge, on New York Harbor, several miles from the center of Brooklyn, about 1896, and utilizing 6,600 volt transmission.

The L. St. Station in South Boston, on Boston Harbor, was originally started in 1898 with reciprocating engines, and greatly enlarged into a turbine plant beginning about 1903.

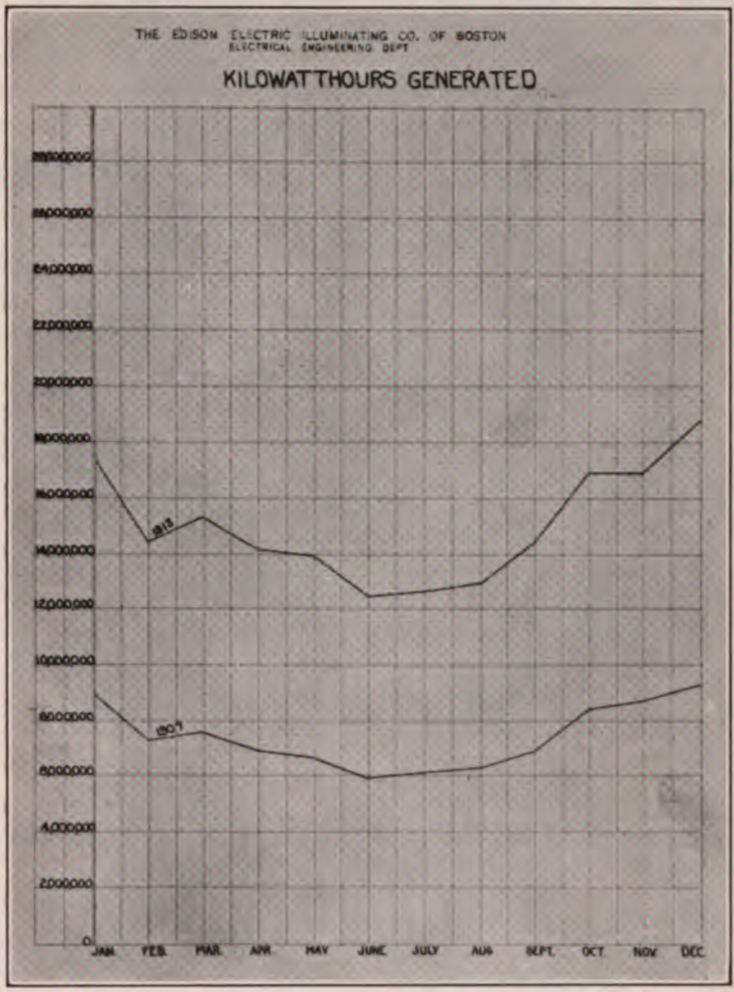


FIG. 2.—Boston, Edison Annual Load Curves, 1907 and 1913.

The recognition of the three principles above mentioned has resulted in an increased public confidence, which has reciprocally resulted in an enormous growth of business as shown by these

several diagrams (Figs. 2 and 3) of increase that have occurred in the electrical distribution business in several of the largest cities.

One marked feature of this increase in large cities has been the gradual transferring of the power generation of the electric railway system to the electric light companies. This has resulted in the shutting down of railway steam plants, and the resulting enlargement of the greater central generating stations of the electric lighting companies, whose load factors have thereby been improved. These railway loads have been added on a tremendous scale, in Chicago, St. Louis, Newark, N. J., Washington, D. C., Philadelphia, and to some extent in New York City, and on a smaller scale in Boston. There are other large cities where the railway and light-

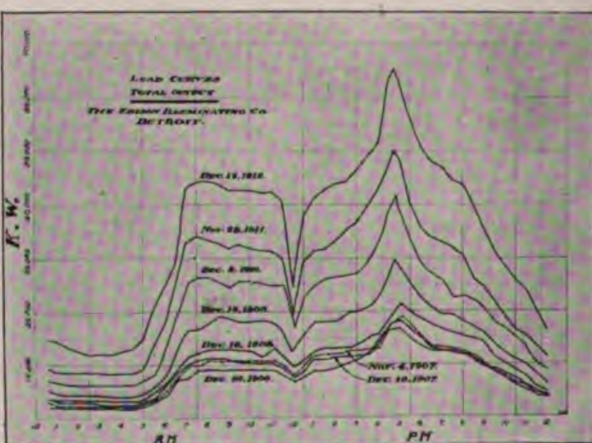


FIG. 3.—Increase of Load at Detroit.

ing business has been combined for operation under one management.

The proportion of railway load to lighting and power loads in St. Louis is about 40 per cent.; in Washington about 50 per cent., and in Chicago it is over 50 per cent. of the total central station output.

The natural result of all this is to further increase the responsibilities of the central station engineers both in the design and the operation of large power stations.

Turning now to the extent of territory covered by some of these large stations, this map of New York City (Fig. 4) shows the

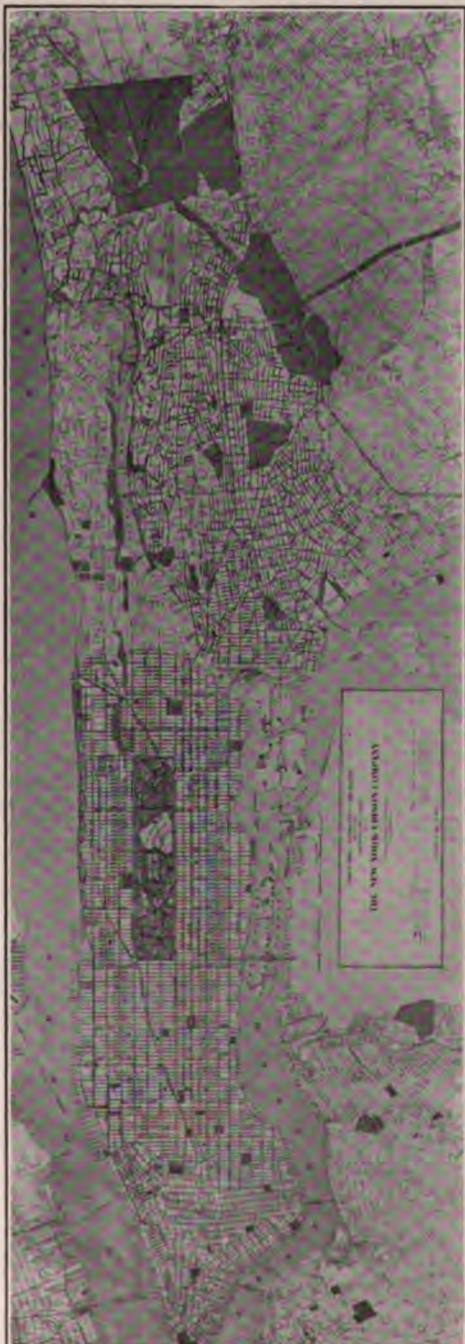


Fig. 4.—New York Map.

location of the principal stations and the territory they serve. Electric lighting development here began with the Pearl Street Station in 1882, which was practically the first Edison Station ever built. As years went by, and before high voltage power transmission on a large scale became available, numerous steam stations of the non-condensing type for direct current generation were built here and there about Manhattan Island. The Duane Street Station with 2,500 H. P. vertical engines is a sample. Power

Fig. 5.—Boston Map.

generation of this company is now chiefly concentrated at their Water-side station at East Thirty-Eighth and Fortieth Streets, where the total installed capacity now planned for is nearly 259,000 K. W.

A new station with an ultimate capacity of about 150,000 K. W. has recently been built at 201st St. and the Harlem River by the United Electric Light and Power Company for 60 cycle alter-

nating service. The New York Edison Company has lately taken over the operation of the Kingsbridge Station of the Third Avenue Railway of about 40,000 K. W. capacity, and is furnishing power to the railway company.

Fig. 5 shows the size of the district covered in the Boston Territory and the location of the central station on tidewater at South Boston. The total area of the district covered is about 700 square miles. Fig. 6 shows the territory of the Chicago Edison Company which about twenty years ago was confined to a space about one mile square in the center of the business district. With the advent of high tension power transmission,

FIG. 6.—Chicago Map.

the first large station at Fisk St. was built, and originally equipped with some of the earliest 5,000 K. W. steam turbines. Later on it was supplemented by the Quarry Street Station, and finally by the new "North West" Station on the other side of the city. Similar conditions have prevailed in Detroit, where the original Edison Station in the center of the city was replaced some ten or twelve years ago by a large station at Delray, several miles south of the business center, which has grown to a capacity of 97,000 K. W., and a new one is now being built on the northerly side of the city.

Station location is determined by the fuel and water supply and also by the cost of land and of foundations.

The great quantities of coal required necessitate unobstructed routes of supply and plenty of room for storage against possible interruption. Moreover, economy of operation requires an unlimited and equal y unobstructed supply of condensing water, while economy of first cost puts a check on total expenditures for real estate and foundations. If land is not too costly, enough is secured to store several months supply of coal, adjacent to the station.

Where coal comes by rail, it is necessary to have plenty of room for side-tracking cars, and it is desirable to be located convenient to more than one railroad, in order to minimize interruption of service and get competition in freight rates.

Where coal comes by water, the channel for boats ought to be free from all obstructions to navigation, such as ice, or drawbridges, at all times.

In either case, yard room for storing coal somewhere near, and preferably alongside the station, is absolutely necessary for the larger stations. If such land cannot be had except at a prohibitive price, the alternative is to provide an outside coal storage yard elsewhere with uninterrupted communication between.

Around New York and other tide-water, ice free ports, coal is usually brought to the station by water. In Chicago, St. Louis, and other fresh water locations, coal supply is chiefly by rail.

In New York City and in St. Louis, coal storage adjacent to the station is not possible on account of the high cost of land, and storage yards outside of the city are required.

On account of its susceptibility to spontaneous combustion there is some danger of loss by fire in large piles of bituminous coal, particularly if the sulphur content is relatively large, and if the coal is piled more than 15 to 20 ft. high.

Here and there in the Middle West, central station companies have begun to store their coal under water. At Indianapolis a concrete walled pit has been excavated which has a capacity of 13,000 tons of coal, which will be kept submerged in water until just before it is used.

The location of the central station with respect to coal and water supply, and the general arrangement of the station building and its equipment, are so closely inter-related that to avoid repetition of the illustrations it is somewhat easier to consider these elements together than separately.

Starting with the Boston Edison plant, the turbine station, now of nearly 100,000 K. W. capacity, is located adjacent to a reciprocating engine station of 9,000 K. W. capacity which was outgrown after only five years' service. The site is directly upon the shore of Boston Harbor. As the coal can be supplied far

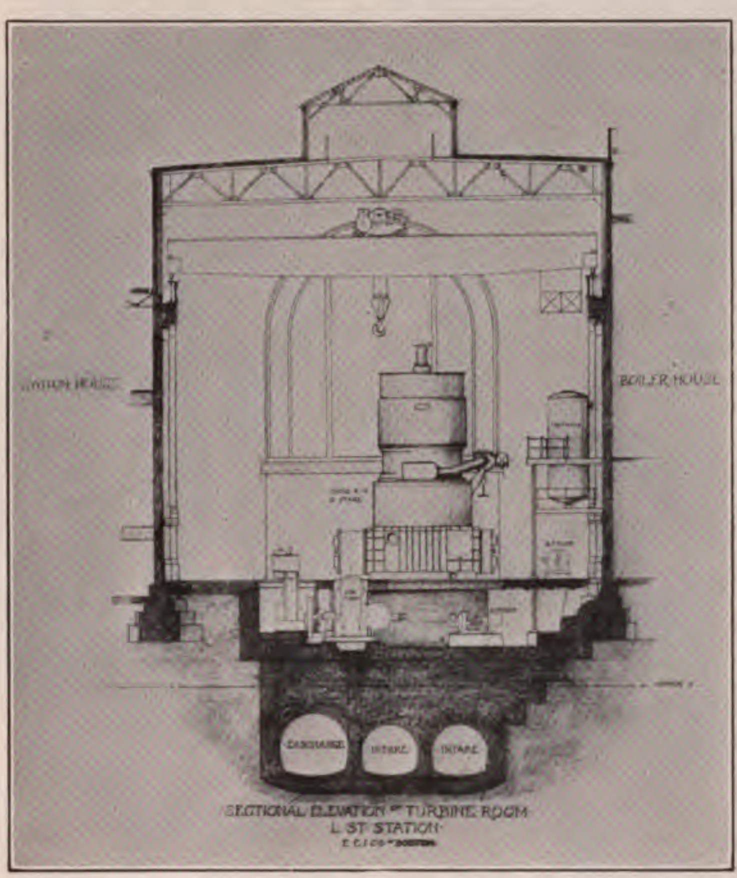


Fig. 7.—Cross-section through L Street Turbine Room.

cheaper by water than by rail all the year round, railroad facilities are not required for fuel delivery.

There are two intake and one discharge tunnels (Fig. 7) for the circulating water running lengthways of the turbine room. The masonry construction of which they are composed forms a base

for the turbine foundations. The conditions for foundation construction were here unusually favorable, consisting of hard clay and gravel, with no quicksand, enabling the entire building and equipment to be carried on natural soil without piling. The harbor ends of the tunnels connect to the gate and screen chambers.

The general arrangement of the station (Fig. 8) is a natural one to adopt where there is sufficient cheap land, and consists of a long turbine house, with the boiler house designed to hold a row of boilers for each turbine and set at right angles to the axis of the turbine house. There were originally installed eight 500 horse-

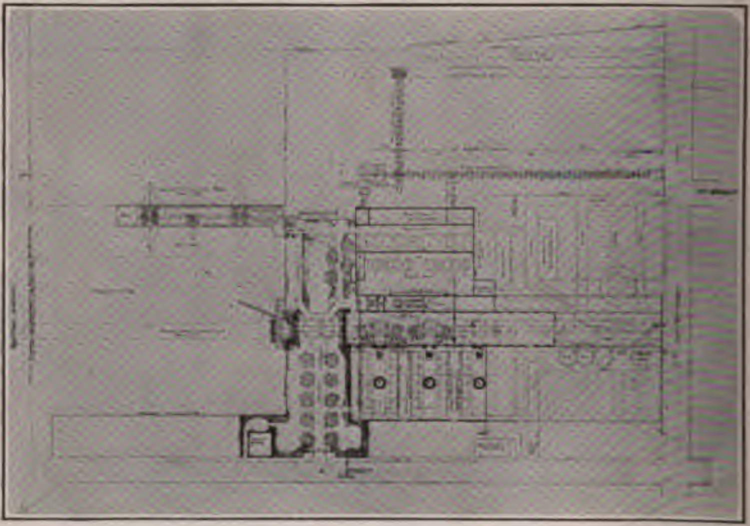


Fig. 8.—General Plan of L Street Station.

power boilers to one 5,000 K. W. turbine. The boiler house is single deck, with separate lines of individual coal bunkers over the boilers, holding about 45 tons per boiler. The original installation called for an ultimate capacity of twelve 5000 K. W. turbo-generators and the condenser tunnels were designed accordingly. The first two 5000 K. W. machines were afterwards replaced by units of 12,000 K. W. The second pair installed were 7,500 K. W. each, the 5th unit 12,000 and the 6th, 7th, and 8th of 15,000 K. W. each—making a total of 96,000 K. W. The improved economy of the larger size and later design of turbine,

combined with the modern practice of getting from 200 to 300 per cent. rating out of boilers at peak loads enabled this increase in turbine capacity to be made without increasing boiler capacity even to the extent that was originally planned. The total capacity of the boiler plant is 24,000 horsepower. The capacity of the condenser tunnels is now about reached. When future additions to their company's plant are made a fresh start will probably

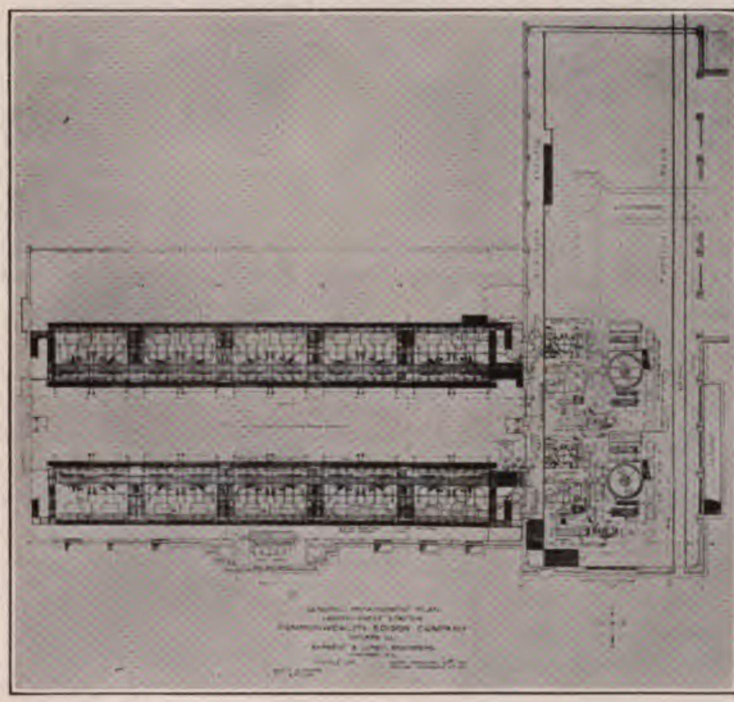


Fig. 9.—Plan of N. W. Station, Chicago.

be taken. This illustrates how the changes in the art, as well as increase in load, tend to cause premature outgrowth of carefully considered original designs.

At this station the coal is stored in the open and alongside the station. The present capacity is about 50,000 tons and the storage can be increased to about 2½ times this amount. The coal is removed from the vessels by two movable steam hoisting towers to

a belt conveyor running beneath them on the wharf, which elevates it some fifty feet and conveys it to the trestle along one side of the storage yard. Two traveling bridges, each equipped with a large grab bucket, distribute the coal from the trestle to the yard or reclaim it from the yard and deliver it to the belt conveyor system from the bunkers above the boilers. The conveyor system from the yard to the boiler house is in duplicate.

Turning now to the Commonwealth Edison Company's new station in Chicago, the Northwest station was planned to consist ultimately of two (2) installations of 120,000 K. W. each. The proposed development consists of a tract of seventy-five (75) acres, to allow for railroad tracks and coal storage, and is located near enough to the north branch of the Chicago River to utilize for condensing water. The river is so small that if the city pumping systems that keep it full from Lake Michigan were to shut down for any considerable time the river water would have to be used over and over again, and the river ends of the condenser tunnels are, therefore, widely separated. Of the four railroad tracks shown in each section of the boiler house two are for coal and two for ash cars. The plan (Fig. 9) shows the arrangement of the buildings generally similar to that shown for Boston, but the transformers, bus bars, and switch-gear are housed in entirely separate buildings, connected by a covered passage way. There are ten 580 horsepower boilers for each 20,000 K. W. turbine and one stack for each ten boilers. The rows of boilers are at right angles to the turbine house, following the unit system of arrangement.

As shown by the sectional elevation (Fig. 10) the stacks are supported on the building framework.

The coal all comes by rail and the handling arrangements are shown in the cross-section and subsequently in the longitudinal section. The cars enter underneath the main Boiler Room floor, there being one coal track and one ash track for each line of boilers, with head-room to accommodate a traveling crane and grab bucket. Such cars as have not hopper bottoms are unloaded by the grab bucket. Coal is dropped into receiving hoppers below the cars, thence passing through a traveling crusher on the level below into a traveling bucket conveyor running the entire length of each boiler house, emptying the receiving hoppers underneath and filling the coal bunkers al[illegible]ilers. The bunker capacity for two units is only ab[illegible]d tons, or forty tons per boiler.

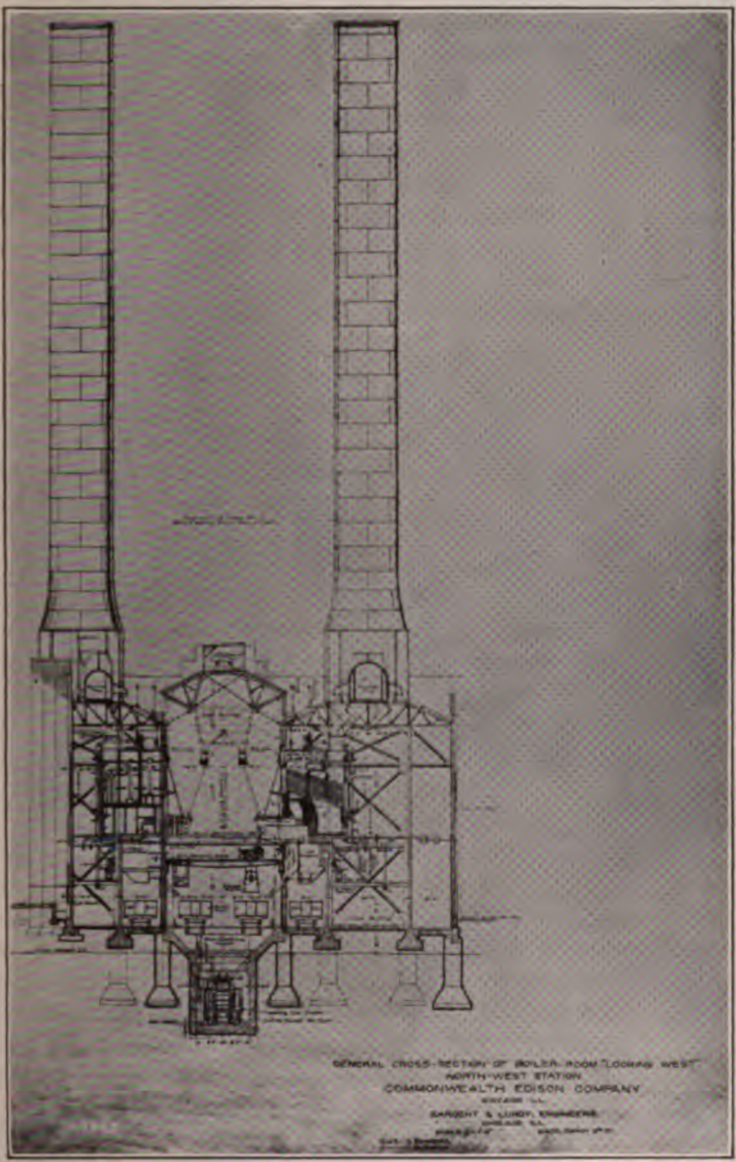


FIG. 10.—Cross-section of N. W. Station Boiler Room, Chicago.

The principal coal storage is in the yard outside, with capacity for several hundred thousand tons. The yard is provided with traveling bridges which can unload the stored coal out of the railroad cars in which it arrives, or take from the pile into the cars that take it into the Boiler House. The total amount of coal stored at all the Commonwealth Edison Company's plants is at present writing about 260,000 tons.

The intake and discharge tunnels are one below the other, running lengthways underneath the turbine room, but do not form any part of the turbine foundations.

Coming now to the city of St. Louis, the situation here is complicated by the presence of the Mississippi River, with a rise and fall of about forty feet. The condensing water supply must be continuous at all stages of the river, and the boiler feed must be taken out of it and purified of mud, refuse, and sewage. Foundations here are on bed rock. The rise in the water requires a coffer-dam construction of the Power Station's foundation and basement, and enables the utilization of the outermost section of the lower portion as a settling tank for clarifying the boiler feed water. This cross section through the north end of the station shows a double-deck Boiler House with a large bunker overhead covering the entire area. The space over the intake and settling tanks is utilized at this end of the station for an ash car track, over which is the ash-bin, and above that the coal tower. Coal arrives mostly by rail but can also be received by barge, if desired, for the greater part of the year. The coal receiving yard is north of the station and cars are run up an incline and can either be dumped into a receiving pit or emptied by the coal tower that can also be swung around over the river and used for unloading barges. Screenings are thus handled direct, but for mine run coal an unloading crane and crusher are installed in the yard, and a belt conveyor handles the coal to the receiving pit, whence the tower handles it to the bunkers. There is practically no yard room for the storage of coal here, so that the Boiler Room bunkers, with a capacity of about 13,000 tons, have had to be supplemented by open air storage at Madison, Wis.

One of the most recent central stations is that built for the Boston Elevated Railroad at South Boston on property alongside the Boston Edison Station, which we have already considered. There is plenty of room here for large development. The station

is located on a tract of 25 acres fronting on the main ship channel of Boston Harbor. The largest vessels can unload coal at the dock. The station building is 600 ft. back from the dock and the circulating water tunnels receive and discharge water at the head of a wide slip, whence they run directly under the turbine room. The ultimate length of the building is designed for the installation of 125,000 K. W. and another station can be built if need be around the same coal storage area to the extent of a total amount of 300,000 K. W. The absence of railroad coal tracks makes possible a large saving in the amount of land as compared with the situation noted at Chicago. The entire coal storage area available

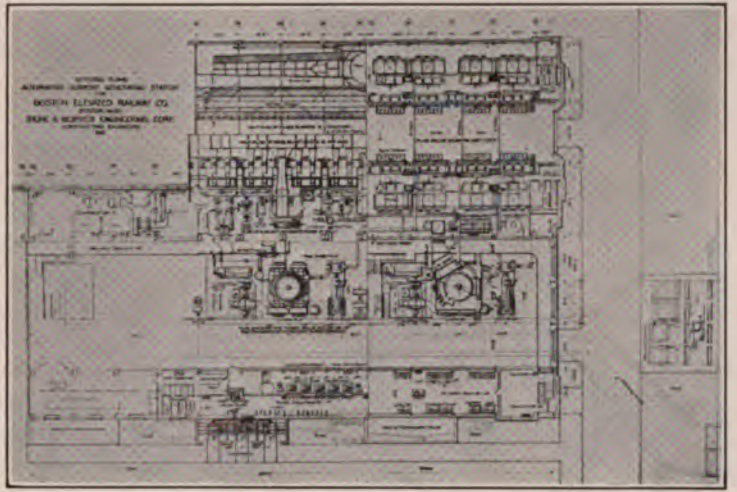


FIG. 11.—Plan of Boston Elevated Station, South Boston.

will hold 100,000 tons. Half of this is now in use; the other half is still to be filled in. This coal storage area is covered by a traveling bridge of 300 ft. span which runs alongside and connects with an elevated cable railway road leading from the dock.

The general plan (Fig. 11) shows a return to the earlier scheme of two rows of boilers parallel to the turbine room. Eight 600 horsepower boilers were installed to one 15,000 K. W. turbine, a ratio of a little over 3 K. W. to one boiler horse power. One additional turbine of 15,000 K. W. has been installed since the station was built, and four boilers will be added to the boiler plant, which

will make the ratio of actual installed capacity about $3\frac{3}{4}$ K. W. to one boiler horse power.

The cross section of this station (Fig. 12) shows a single

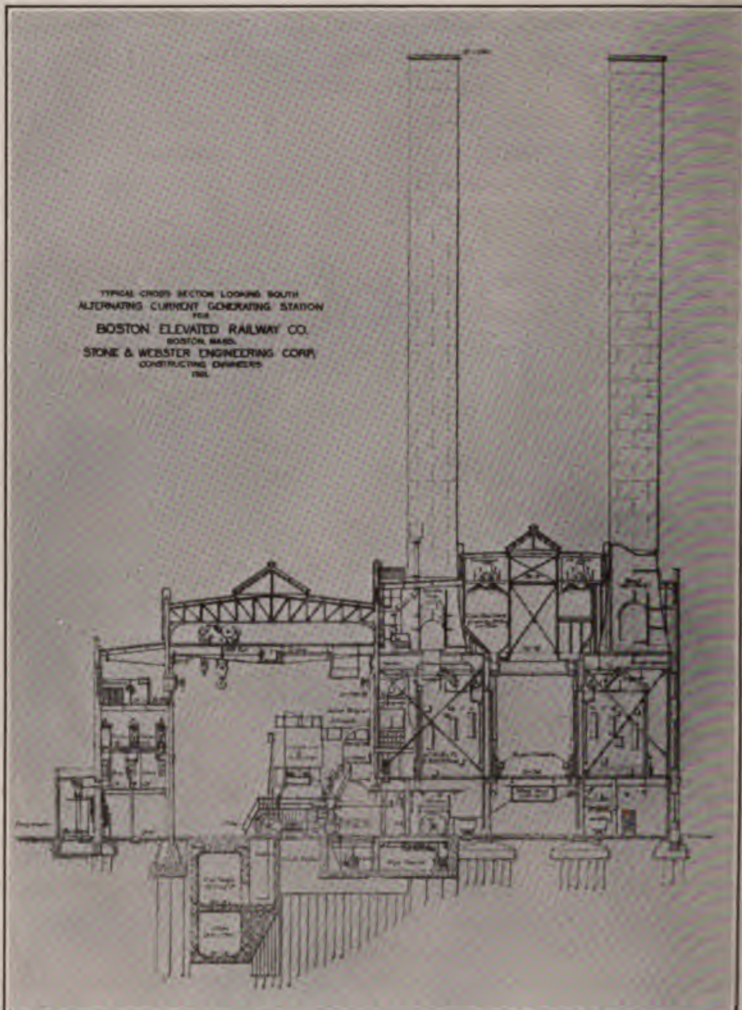


FIG. 12.—Cross-section Boston Elevated, Including Stacks.

decked boiler room with steel stacks supported on the boiler house framework, very heavy girders and columns being provided for this purpose. This preserves the symmetry of the layout of boiler

house equipment and saves space. Although the stacks are high enough to provide natural draught for ordinary grates, the adoption of under-feed stokers requires forced draught, for which fans and ducts are installed in the boiler room basement.

The foundation of the building and equipment are here all on piles. The turbine foundations are at one side of the circulating water tunnels. The feed water heaters and weighing tank are grouped in rear of the inner line of boilers. Below this part of the boiler room floor, the turbine room wall is arched so as to make the space under the rear of these boilers a part of the turbine room floor, and here most of the steam driven auxiliaries are located. The arrangement of the electrical switch galleries is conventional, being in a section of the building parallel to the turbine room, and partitioned off from it.

The coal bunkers over each boiler have 80 tons capacity each. The coal is distributed to the stokers by an overhead traveling hopper running lengthwise of the fire room which can receive coal from any bunker and deliver it to any stoker. Ashes are dropped from the ashpits into small dump cars and are used for filling in the coal yard.

We have already noted that in New York City power for the Edison Company's system is chiefly generated at the Water-side station on the East River. This station is composed of two plants; No. 1 was built in about 1900 and No. 2 about 1906. Each occupies a separate block on the East River front, No. 1 reaching from 38th St. to 39th St. and No. 2 from 39th to 40th. The foundations here are directly on bed rock. As in the case of the Boston station there is no railroad track service. Coal is brought in barges from coal docks in New Jersey by way of the East River, which also furnished the condensing water. The original station was planned for sixteen 3,500 K. W. alternators driven by vertical engines. After eleven of them had been installed, the equipment was completed by five turbine units of various capacities from 5,000 to 10,000 K. W., all of the vertical type. Since 1911 four of the engines have been replaced by three 20,000 K. W. turbines, making a total of about 120,000 K. W. The boiler plant is double decked with a total of 56 650-horsepower boilers in Station No. 1, set in batteries of two.

The boiler room and engine room of No. 1 Station are parallel. The condensing water tunnels run lengthwise directly under-

neath the engine room basement where condensors are located. 10,000 tons of coal can be stored in the overhead bunkers, being taken from boats by coal towers placed on the bulkhead, the hoisting bucket discharging into the crusher, thence by belt conveyor to a weighing hopper, then elevated directly by bucket conveyor to a monitor over the boiler house where a horizontal conveyor distributes it to the bunkers. The engine room and boiler room are parallel but the electrical gallery is at the west end of the engine room.

As this station was rapidly outgrown, Water-side Station No. 2 was built in the adjoining block. Here the turbine room is at right angles to the river as in No. 1, but a larger boiler house is required and ninety-six 650 horsepower boilers were installed on two floors, with firing aisles at right angles to the turbine room, six boilers on each side of each aisle. The Boiler House is next to that of No. 1 Station for convenience 'n connecting the two steam piping systems. The exciter batteries, bus room, switch rooms, and electric galleries fill an eight-story section along the 40th St. side of this station, and parallel to the turbine room. The operating room and offices are built across the west end.

The coal bunker extends over the entire length and almost over the entire width of the Boiler Room, having a capacity of 20,000 tons. The coal is hoisted by clam shell buckets out of boats into two high-level towers, whose receiving hoppers are 187 feet above tide-water. The coal then falls through a chute to a crusher and then to cars on the track scales. These cars are run around on a high-level cable railroad and make a circuit of the bunkers. The capacity of this plant is 200 tons per hour with a maximum of 300 tons for short periods. The ashes are dumped from the ash hoppers into cars in the Boiler Room basement which in turn dump into a bucket conveyor and then into a big ash hopper of 1800 cubic yards capacity, located in the coal tower structure on the dock, from which they are discharged into scows.

A duplicate system of hoisting the ash cars to dump directly into the ash-bins is provided in case of a breakdown of the conveyor system. The capacity of the ash handling system is 50 tons of wet ashes per hour.

Having become familiar with the general arrangement of some of the largest stations in the country as regards location and arrangement of equipment, it is well to touch for a few minutes on the subject of architecture of the central station buildings.

FIG. 13.—Atlantic Avenue Station, Exterior.

FIG. 14.—Old L Street, Exterior.

Fig. 15.—New L Street, Exterior.

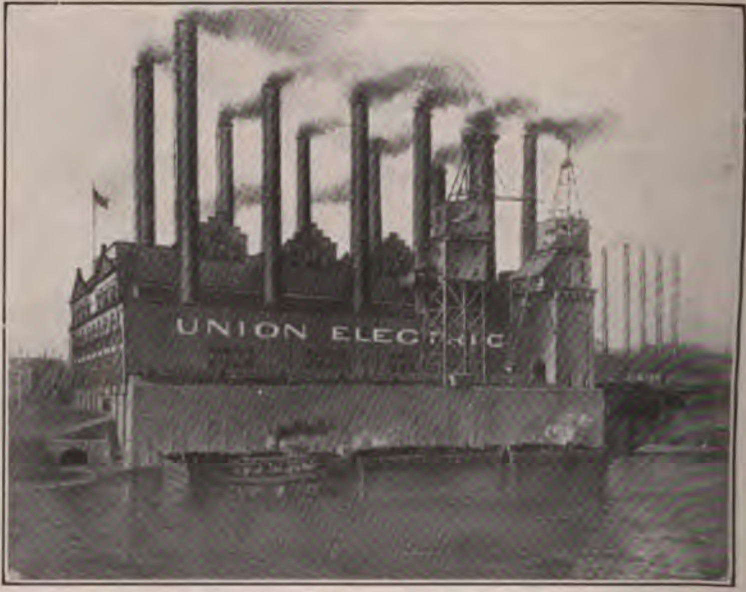


Fig. 16.—St. Louis Station, Exterior.

Some of the earlier plants were built without showing any pretensions to architectural effect, particularly when located in remote or unsightly places. The Atlantic Ave. Station at Boston, built in 1891 on a city lot next to the Harbor, had a dignified street facade, otherwise its location in the block permitted no special effort at ornamentation. The exterior of the old L Street Station, built by the Boston Electric Light Company in 1898 at South Boston, was quite unornamental, its external aspect being utilitarian and nothing more, while the interior was good. When the new station was built in 1904, however, considerable thought was given to the architectural effect, both within and without. The external treatment is as shown in the attached picture. Fig. 16 shows the St. Louis station, whose walls and gables, visible in the picture, also indicate a recognition of the fact that a building for such a purpose and essentially of massive proportions and construction should reflect its dignity and importance in its architecture. The South Boston Station of the Boston Elevated is also pleasing and harmonious in this respect. The two large Waterside stations in New York City have had much architectural detail expended upon them in a manner to make them impressive as to handsomeness, as well as for size and importance.

The Bennings Station (Fig. 14) of the Potomac Electric Power Company of Washington, D. C., is an instance of what a pleasing architectural effect can be produced by a structure which is essentially simple and has nothing but straight lines in its composition. The combination of the grouping of the different masses so that they help to set each other off, and the proportions of the paneling and cornices and parapets have been utilized to produce an effect with practically no expenditure whatever for ornamental detail. This Station is said to have a record of building cost per kilowatt installed much below the average, yet it is far above the average in external appearance, much more so than any other building in the city used for a similar purpose. It partakes of the character that should be expected of an important public utility in the National Capital. Instances such as the foregoing are excellent examples to engineers in other cities who look forward to such problems in the future. An important public utility building is now expected by the public to be something more than utilitarian in appearance. The central power station is nowadays as much of a public institution as a postoffice, a library, a bridge, a

City Hall, or a National monument, and the foregoing examples have shown how dignity, power, and beauty can find expression in central station architecture.

The water tube boiler of the Babcock and Wilcox type with superheater is practically the standard type now adopted for large power station construction all over the country, although a modification of the Stirling type has lent itself to the construction of the largest unit yet built, viz., 2,365 horsepower, which takes about half the cubic space and about one-fourth the floor space per horse power of the usual size boiler. Most Babcock and Wilcox

Fig. 17.—Potomac Power Company Station.

boilers for central station work are in sizes of from 500 to 650 horsepower. Central station engineers do not yet seem quite ready to generally adopt units of larger size chiefly because a larger proportion of boiler capacity would be thrown out of service by the failure of a single boiler tube, or by any other occurrence that necessitates cutting out a boiler. This is of particular importance where boilers and turbines are laid out on the unit system. Another reason for keeping to the present standard sizes of 500 to

650 horsepower is the experience obtained during the past few years in running boilers at 200 to 300% of rating at peaks. Generally speaking, the peaks are of short duration, ½ to 2 hours, and the efficiency at the greater rating is so little lower for this short period that both the interest on the lower first cost, and the savings by banking fewer fires, over-balance the small loss in efficiency at peaks.

It is now possible to allow 3½ to 4 K. W. capacity of turbine for each boiler horse power instead of 1 to 1½ as formerly.

Station pressures are slowly rising, being frequently 175 to 200 lbs., and in the Northwest Station the pressure is 250 lbs. Superheat varies from 100° F. to 200° F. usually the former, and is commonly produced in the superheater located in the boiler itself over the second pass. Boilers usually have the customary settlings of ordinary brick. Some engineers have tried enclosing the brick setting in a steel casing, of which the St. Louis plant is an instance. This is done in order to increase boiler efficiency by preventing infiltration of air through the brickwork, but results have not yet been convincing enough to spread the practice widely.

Automatic stokers have for many years been considered a necessary part of central station equipment and all the largest stations have them. There are three general types: the traveling grate, the over-fed inclined grate, and the underfed type. In the Middle West where much low grade coal is used, the chain grate with a long reverberatory arch over it has proved very successful.

In the Northwest Station at Chicago the chain grate stoker with two different types of baffling in the boiler tubes were used and were installed to ascertain which gave the best results in respect to smoke prevention. In the East the other types of stoker are generally preferred especially where coking coals are used. The Boston Edison installation is composed almost entirely of Murphy stokers. The New York Edison has both the Roney and Taylor stokers. The Potomac Power Company in Washington employs mostly the Roney, some Taylor stokers having been recently added. The under-feed stoker, of which the Taylor is the most widely used, requires a powerful draft for the thick fire carried, and this requires a fan installation.

During recent years the municipalities have been enforcing more strictly their regulations about the emission of smoke from chimneys, and it has become necessary for Central Station engineers

to plan their boiler and furnace installations as much with reference to observing the smoke ordinances as for efficiency of operation. It is now a well recognized fact that combustion can only be complete when the combustion chamber is of sufficient size to permit the combustible matter in the coal to be thoroughly combined with oxygen before the gases are cooled by the boiler tubes. Unless the volatile hydrocarbons can be burned by being forced through the fire, as is the case with the under-feed stoker, furnaces of the Dutch oven type with large combustion chambers are a necessity for the usual sizes of the boiler. The chain grate and the Murphy type of furnace lend themselves readily to this construction.

The 2,400 horse power boilers of the Detroit Edison Co. have enormous combustion chambers, which contribute greatly to their high efficiency and enable the effective prevention of smoke.

The attention of engineers is being directed more and more to securing better economy in the Boiler Room. That is the point in the station where intelligence in watching and following conditions ot boiler operation will instantly result in appreciable fuel economy, while slackness or indifference will invariably cause large losses.

Large central stations are subject to great and sometimes very sudden fluctuations of load. For years the electrical end of every station has been very completely equipped with accurate and expensive indicating and recording instruments, but it has only recently become the practice to install instruments in the Boiler Room to give the firemen some corresponding information of the work their boilers are being called upon to do.

Recently visual load indicators have been mounted in the fire rooms to warn the firemen of changes in load. The next instrument to be exploited was the CO_2 recorder, a device for making a continuous record with respect to the CO_2 content of the flue gases. Being naturally a delicate instrument, and one whose operation is not easily understood by the class of help commonly employed in fire rooms, it has not given universal satisfaction and it has to be handled with great care. It is now well recognized that a high CO_2 content of flue gas alone is not the best all round test for the efficient boiler operation, and the samples of the gas may vary so widely when taken from different points in the flue that the recorder is not always given correct samples to analyze.

One of the most satisfactory instruments yet devised for keeping track of steam boiler performance seems to be the steam flow meter, which, when applied to the steam pipe of a boiler and mounted in plain sight on the boiler front, tells the fireman just how many pounds of steam his boiler is evaporating at any instant and enables him to regulate the fires accordingly. Used in connection with draft gauges, draft regulators, and feed water regulators, the coal can be fed into and burned in the furnace somewhere in proportion to the demand for steam, and therefore burned more efficiently.

The automatic regulation of the draft here referred to is not the common damper regulator which is controlled by the steam pressure, but a simple little device mounted alongside the furnace wall, consisting of a diaphragm which is actuated by the pressure or vacuum existing in the furnace, the idea being to keep the furnace conditions constant for a predetermined load. This device is very useful where forced draft is used, in which case the draft regulator controls the fans or machinery for producing the forced draft, and not the damper in the flue. Drawing a parallel with the electrical instruments, the draft regulator just described corresponds to the voltage regulator on the electrical system, and the steam flow meter to the ammeter. Imagine, if possible, the joys of trying to run a large central station and get good service without either the ammeter or the voltmeter; and yet to a certain extent this is what has been expected of the firemen.

Due regard for the rights of the public requires that the products of combustion be taken well up into the air, hence a tall chimney has been used in connection with a large boiler plant. In the past, engineers have felt that the natural draft obtained from such a chimney ought to be sufficient for the operation of the furnaces. At present, however, the need of more positive control over the draft, and of securing high draft pressure almost instantly to meet some sudden demand, is leading to the introduction of forced draft apparatus; and the objections which many people formerly had to the types of stoker requiring forced draft are in a measure disappearing.

The ideal arrangement seems to be an automatic stoker which normally runs on natural draft, with some cheap apparatus for materially increasing this draft by putting pressure under the grate to meet heavy peak-loads and unexpected demands. Such

is the arrangement at the L Street Station, South Boston, where, by means of steam jets, boilers are operated for peak work as high as 300% of rating, and with the boiler running about normal its output can be doubled within a few moments.

In very large stations great care is now taken to keep the feed water pure, not only with respect to solid matter, but also to the alkalies in solution. At St. Louis, where the Mississippi River water is very turbid and also carries a great deal of scale-forming matter, it is treated with the addition of lime and iron and run through a series of settling tanks where the worst impurities are thrown down. Analyses are made daily to follow changes in water content and to enable slight changes in the treatment to meet them. By the use of the Coagulant House the Company treats its water at a cost of about $150 a month, whereas when City water was used the cost was $3,000 per month.

With the present tendencies to force boilers above the nominal rating, and in so doing to increase the circulation, it becomes more necessary to remove the scale-forming ingredients from the water so as to lessen the risk of burned out tubes, particularly over the hottest places in the furnace. A bit of scale dropped in a tube exposed to flame may cause a burned or bagged tube in a very short time. The purer the water the less frequently will boilers have to be blown down and the less makeup water required. It has even been proposed in large surface condensing plants to use distilled water for the makeup.

With feed water that does not require filtration, the open type of heater is useful as a purifier, and is for this reason widely used in the Middle West, where feed-water frequently carries a large amount of scale-forming matter in solution.

Even in a surface condensing plant where the amount of make-up water, from outside, is a minimum, the open heater is more economical than a closed heater, because all of the heat units in the auxiliary exhaust are utilized by its direct mixture with the feed. The only precaution required is that where reciprocating auxiliary engines are used an oil separator must be provided, to keep the cylinder oil out of the heater; but this is not necessary where the auxiliaries are driven by steam turbines, a practice which is becoming more and more common.

Economizers have not been widely used in large central stations, for although at times of peak load they can extract from the flue

gases some heat that would be otherwise wasted, the cost of operating and maintaining them for the rest of the time is enough to largely counter-balance this saving. The net result is usually not large enough to justify the economizer unless the load factor approaches that of a manufacturing plant, or unless coal is very dear, or where there is some special reason for needing the storage of a large quantity of hot water to help out the boiler plant.

The extension of the Fisk St. Station in Chicago is being fitted with an economizer installation, but on a plan different from that usually followed in past installations, in that there is to be a separate economizer for each battery of boilers, each with its own induced draft fans. This scheme will obviate some of the objectionable features of the older type, where one large economizer installation usually handled all the flue gases from a considerable number of boilers.

In very large stations provision now has to be made for the proper admission of air to the boiler room for combustion, particularly where natural draft is used. The required quantity is so enormous that in order to make the boiler room habitable in winter time it is desirable to handle the air, necessary for combustion, through the ashpits, and not through the firing aisle.

The present day tendency is to improve economy in the boiler room, where the coal is being burned. Engineers are now recognizing, and it has been proved by actual experience in Detroit, that if men who rank as skilled mechanics are employed as firemen, they can be trained to become combustion experts. This becomes possible through their ability to follow the indications of steam flow meters, draft gauges, CO_2 recorders, and similar instruments of precision which are now found to be indispensable in the fire room as are electrical instruments on the station switchboard. This class of men are able to appreciate the relations between cause and effect in the combustion of fuel, and with proper instruction and practice can learn to burn coal economically under the exacting conditions of central station operation.

When it is considered that about 60 to 70% of the cost of central station operation is fuel cost, as shown by this chart of costs in St. Louis, the importance of raising the standard of the boiler room personnel is self evident.

The economy of the power station, between the boiler room wall and the transmission line, depends almost entirely upon the

construction engineer who designs the plant. The operative force cannot affect results much in this part of the plant except by improper loading. But in operating the Boiler Room the constructing engineer is nearly helpless, and the real economy of the station is in the hands of the operating force. The variable elements entering into the economical generation of steam offer endless opportunities for head work on the part of the operating employees.

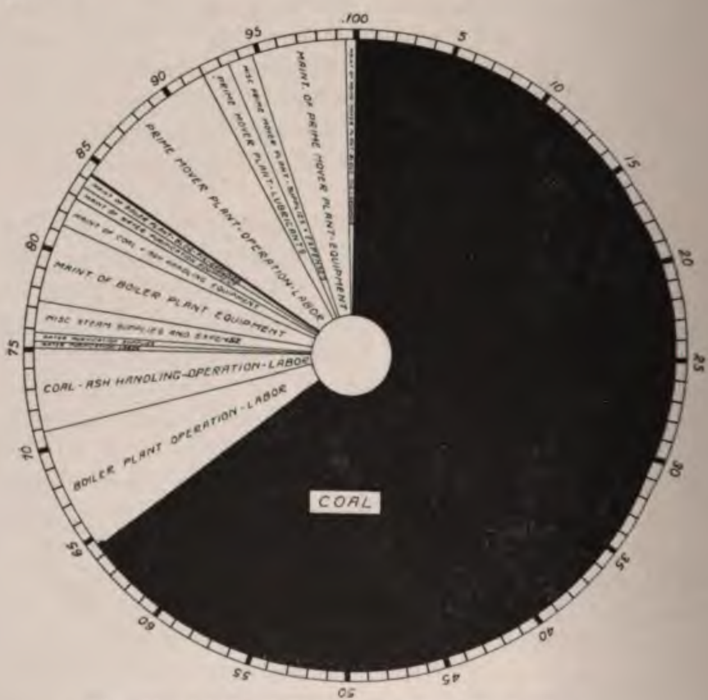


Fig. 18.—Chart of Station Expense, St. Louis.

By cutting down manual labor to a minimum by providing proper instruments, and by suitably arranging the boiler rooms and equipment and the conditions of work, the most important economic task in station operation can be made to appeal to the intelligence of trained mechanics.

Results can thereby be secured in the economical burning of fuel that will greatly reduce the unit cost of electricity.

It is claimed by the engineers of the Detroit plant that the

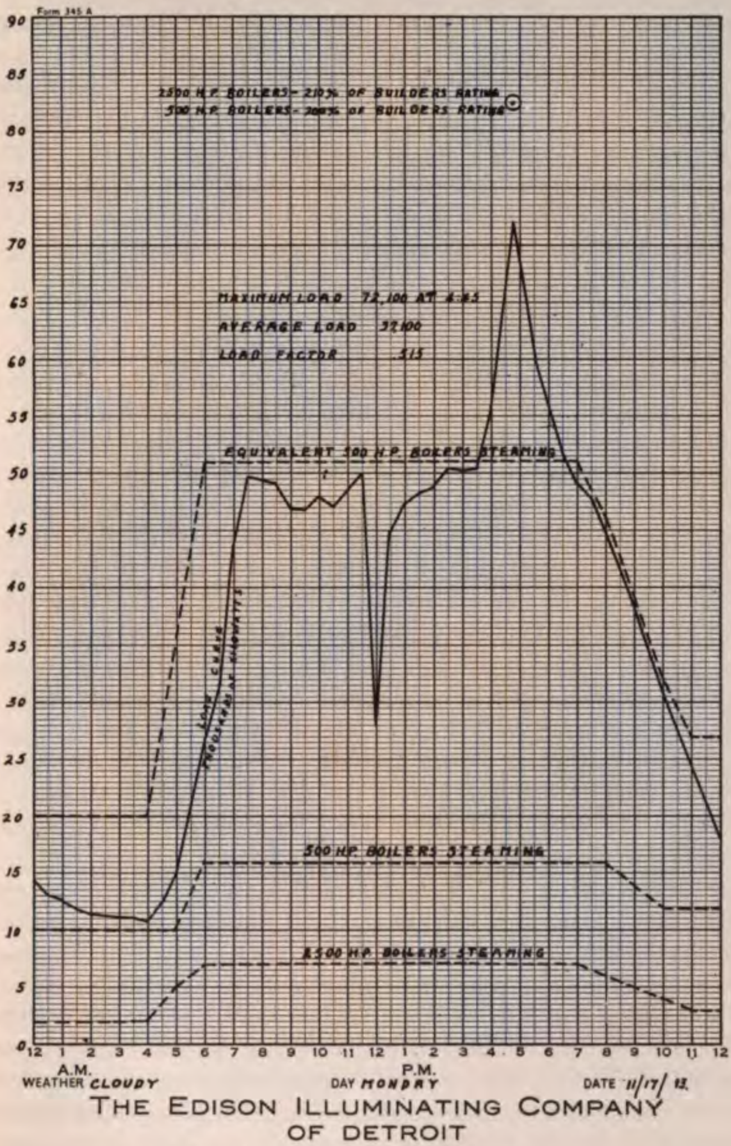


FIG. 19.—Detroit Boiler Operation.

number of skilled firemen can be reduced by increasing the size of the boiler units, and they advance this as an argument for the use of very large boilers. This curve sheet shows the relation of the load curves to the number of large boilers in service at Detroit.

Coming now to prime movers, the first steam prime mover on record is that of Hero of Alexandria about 130 B. C. The principle of operation is that of the reaction wheel. This turbine is said to have been used for opening doors of a temple by means of concealed ropes and in a manner to heighten the mystery of the temple worship. The reaction principle as applied to steam motive power was laid aside and forgotten for centuries, but it was finally revived toward the end of the nineteenth century, chiefly through the work of the Hon. C. A. Parsons of England, who developed a reaction turbine, and by the year 1888 had constructed a machine large enough to run a 25 kilowatt electric generator, which was actual y used on board ship. By 1896 the small steamship Turbinia had proved the commercial practicability of the turbine. In 1898 George Westinghouse built a set of steam turbines with electric generators, large enough to run one of his shops at Pittsburgh, and in 1901 the Hartford Electric Light Company purchased from the Westinghouse Company and installed the first steam turbine and generator put in commercial service in a central station.

In the meantime, the General Electric Company had been experimenting with the Curtis Impulse turbine and in 1903 they were far enough along to install the first 5,000 K. W. turbine at the Fisk St. Station of the Commonwealth Edison Company, Chicago, which was the first one of their large machines to go into commercial service. This was followed by a 4-stage machine of same size, with condensor base, at the Boston Edison Station. Development from this on was very rapid. After a few years experience with sizes of 5,000 K. W. and under, turbine manufacturers began to increase to 7,500, 10,000, and 15,000 K. W. which is the size used in the Boston Elevated and Edison Stations, and to 20,000 K. W., installed at the Waterside Station; and they have recently designed a turbine of a capacity as high as 35,000 K. W. in a single unit. This increase in capacity has been accompanied by increase in the turbine speed, which has enabled modern machines of very large capacity to be built that are little if any larger in over-all dimensions than some of the earlier machines of very much smaller output.

The Parsons or Westinghouse machines are always built horizontal and follow the reaction type. The Curtis machines are of the impulse type, and, until the recent development into higher speeds, were nearly always built with vertical shafts. Experience with both types has led to a tendency to merge some of the characteristics of both machines, in the more recent designs. For instance, the Westinghouse Company in their double flow type has adopted the impulse principle for the first high pressure

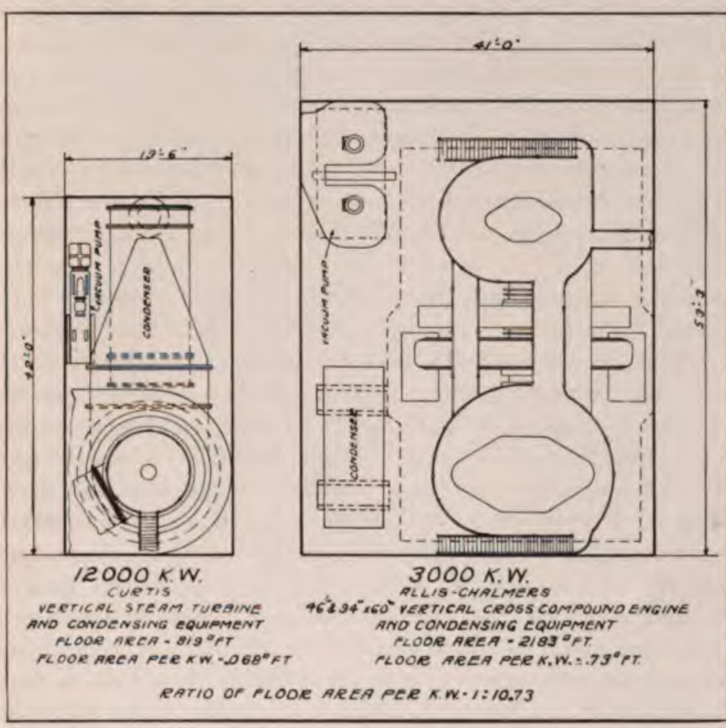


FIG. 20.—St. Louis, Relative Area of Engine and Turbine.

stage, in which a single set of impulse buckets replaces several rows of very short reaction blades. The result is that the spindle is considerasbly shortened, and the flow of steam in the reaction element is divided so that the axial thrust against the blades is balanced in the spindle itself instead of requiring counterbalancing by dummy pistons as in the original single flow type. The Curtis turbines of large size and high speed are now built horizontal,

and show a saving in weight and greater accessibility for repair. The latter is due to the fact that the steam and electrical ends can be taken apart separately, without disturbing the other.

Fig. 20 shows the relative floor area taken up by the original piston engines and steam turbines at the St. Louis Power Station. Here the ratio of space occupied per kilowatt is about one to ten in favor of the turbine. Fig. 21 shows this contrast, in the engine room plan at St. Louis. The large four-cylinder compound engines built for the Manhattan and Interborough Railway Power Houses in New York City about twelve years ago were of about 7,500 K. W. each and occupied about four times as much floor space as the equivalent steam turbines and generators which came along a few years later. Nowadays the ratio would be even greater but practical comparisons between reciprocating engines and steam turbines for stationary practice are hardly feasible now, because no engines larger than 7,500 K. W. have ever been built for generating current.

Although it frequently happens that vertical turbines can be so placed as to take up less horizontal floor area than horizontal ones, they require considerable extra height to allow for crane service, and the resulting CUBIC FEET OF SPACE of turbine room per kilowatt installed is quite likely to show a balance in favor of the horizontal turbine if an effort is made to economize space.

The Westinghouse Company in America and the Parsons Co. in England have recently developed a system of reduction gearing, for operating, by means of steam turbines, such generators as are required to run at speed considerably lower than the economical speed for the turbine itself. They have also applied the same principle to the propulsion of steamships; and to drive direct current generators, such as the 3,750 K. W. D. C. Westinghouse generator at Cleveland, Ohio, which is said to be the largest direct current machine yet built, the gear ratio being about TEN TO ONE.

The largest turbines in operation today are installed in the Fisk St. Station of the Commonwealth Edison Company. (Fig. 22) shows a 20,000 K. W. General Electric Company machine which is run at 1,200 revolutions per minute. Fig. 23 shows the 25,000 K. W. Parsons turbine built in England. The high pressure and low pressure portions are in two separate stages, the low pressure end being of the double flow type. The guaranteed steam

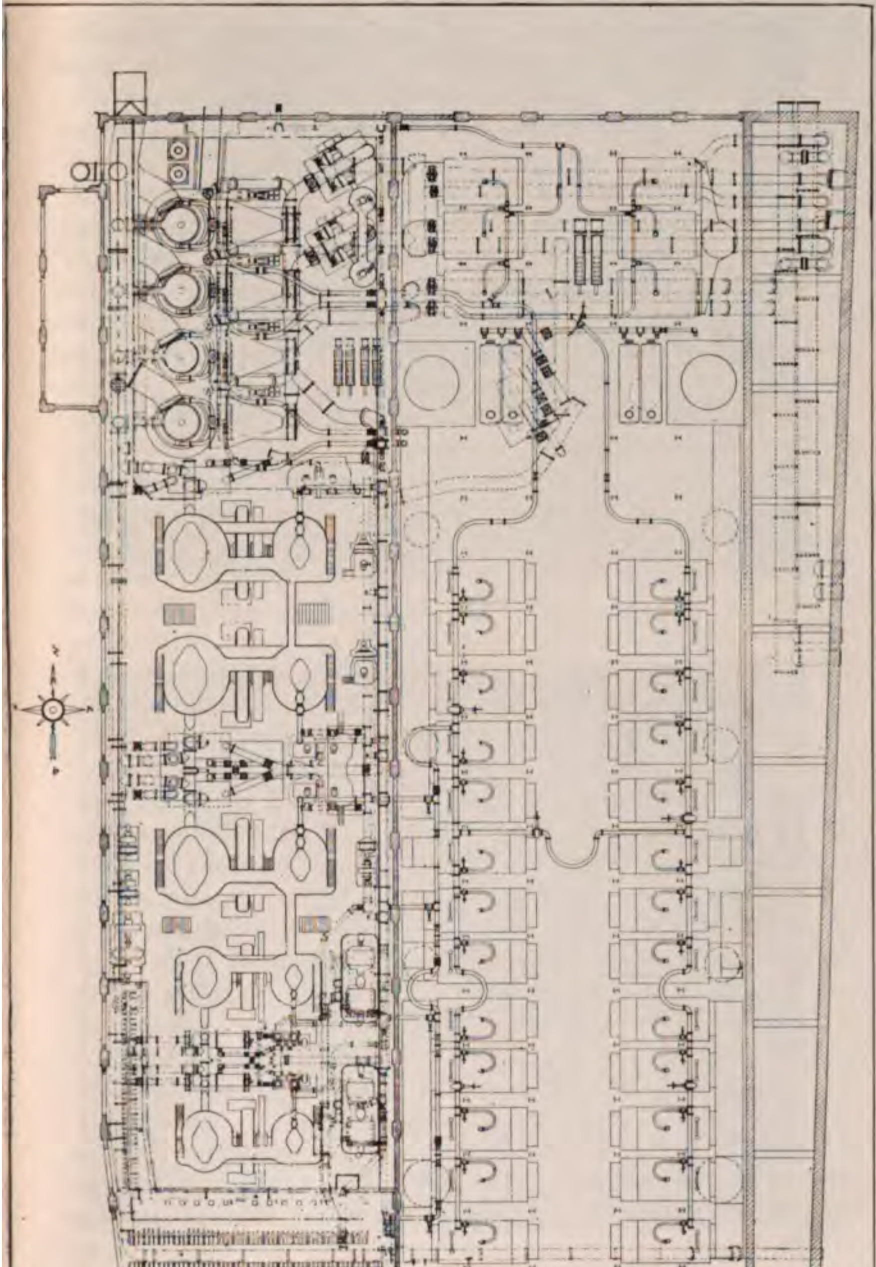


Fig. 21.—Plan of Engine Room, St. Louis.

Fig. 22.—Horizontal 20,000 K. W., General Electric.

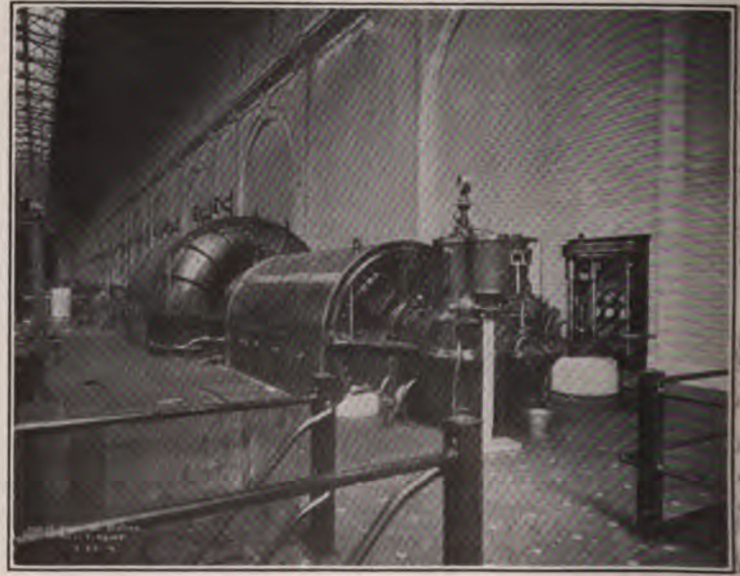


Fig. 23.—Horizontal 25,000 K. W., Parsons.

consumption of this unit is 11.65 lbs. per K. W. hour at 25,000 K. W. output with 200 lbs. pressure and 225° of superheat and 29 inches vacuum in the condensers.

A still larger machine, 30,000 K. W., has been designed by the Westinghouse Company to be installed by the Interborough Rapid Transit Company in their 74th St. Station in New York City. This is being built in two units; the high pressure unit is to run at 1500 revolutions, and the low pressure at 750 revolutions per minute. Steam pressure 200 lbs., superheat 125°, and vacuum 29 inches permit a steam guarantee of 11.27 lbs. K. W. hours at 30,000 K. W. output. The Rankine cycle efficiency of the combined units is guaranteed to be 75%, which is said to be lower than for any machine yet designed. By dividing the machine in two parts, the builders claim that most efficient relations between steam velocity and blade velocity are secured both for the high pressure and the low pressure blading.

Installations of this type by availing themselves of the largest units, with the high superheat and the low vacuum which it is now possible to secure, combined with the more efficient operation of boilers and furnaces which has been above indicated, can now with a load factor around 35% put out a K. W. hour on less than 2 lbs. of high grade coal. This corresponds to about 26,000 B. t. u. per K. W. hour output.

Surface condensers are generally used in the larger installations. They enable the use of purer boiler feed water, all the heat that goes to the hot well is reclaimed, and the highest possible vacuum is obtained. Even where a large supply of fresh water is available for boiler feed, the majority of situations are such that feed water has to be treated in some way before it is fit to use. The all-important question of pure feed water is therefore practically independent of whether the condensing water supply is fresh or salt, and favors the use of surface condensers particularly as the proportion of make up water required to replenish the losses in a well operated station should not exceed 5 to 8%.

The question of condenser tube corrosion seems to have narrowed down to a search for an alloy of high heat conductivity which is not deteriorated by the treatment it receives during manufacture, and is not subject to local galvanic action between particles of the different metals in its composition, and is not affected by the presence of impurities in the condensing water.

In a turbine there is no waste from cylinder condensation. The steam can be expanded to a much greater volume and consequently lower pressure than is physically possible in an engine. Consequently, the development of the turbine has caused a correspondent improvement in the condenser. The practical limit of vacuum possible with piston engines will average about 26 inches (formerly it was much less) while with turbines 28½ inches has been easily attainable for some years and now the latest standard specifications call for 29 inches. This makes possible a considerable gain over engine practice in the conversion of heat into work. The ratio of circulating water to steam condensed, for a turbine, is two to three times that of a piston engine.

The cooling surface in the condenser of the 25,000 K. W. Parsons turbine in Chicago is a little less than 40,000 sq. ft. This is about 40% of the cooling surface per Kilowatt which was thought necessary ten years ago.

One feature of the design that is now receiving considerable attention is the distribution of the tubes to facilitate the flow of the vapor through the condenser. In the large units, the enormous quantity of steam and the high velocity at which it leaves the turbine have been shown to require more room for entering into contact with the tubes than has often been left for it. Fig. 24 shows a base condenser of older design accompanying the 5,000 K. W. Curtis turbine at L Street Station with layers of tubes extending close up to the exhaust inlet of the condenser. It has been found that the removal of a number of rows or layers of tubes so as to create better steam passages between them resulted in a materially better vacuum, even though the cooling surface was decreased.

The station auxiliaries are numerous and comprise the pumps for boiler feed, for the condensing system, for the turbine oiling system and the general service pumps; also the exciter generators, the coal and ash handling machinery, blowers for forced or induced draft, the drive for stokers, etc. The question of what motive power to apply to these auxiliaries depends to some extent on the disposition of the exhaust of the steam driven auxiliaries, and also the location of the apparatus.

Generally speaking in large stations steam auxiliaries are used and the exhaust is passed into the feed water heaters. It may be sufficient to heat the feed water to 200° but in very large modern

stations the auxiliary steam exhaust is usually only sufficient during times of light load, requiring an extra supply of steam from other sources during the times of heavy load when the auxiliary exhaust is not increased in proportion.

One method of supplementing the feed water heaters at peak loads is by bleeding steam from one of the intermediate stages of the main turbine unit. The question of the best combination of apparatus for getting into the feed water as much as possible of the heat that would otherwise be wasted is one that has to be studied carefully for each individual case, having regard for over-

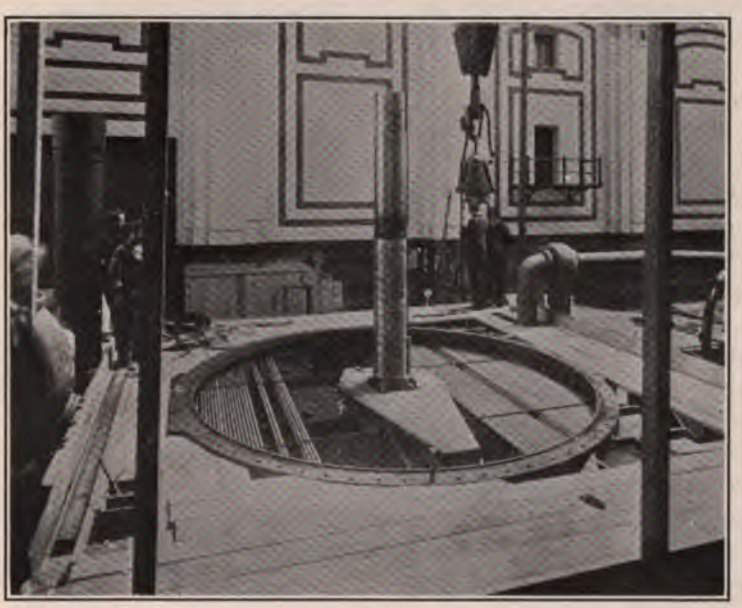


Fig. 24.—Old L Street Condenser.

all economy, fixed charges and operating expense. The pumps, blowers, and stoker engines about or near the boiler or turbine floors are usually steam driven. Remotely situated apparatus is often better operated by electric drive. Exciter generators are frequently installed in separate steam driven and electric driven outfits, which are used interchangeably upon the exciter bus bars. The very intimate dependence of continuity of service upon the exciter system also requires the use of a storage battery,

floating on the exciter bus, in connection with both electric and steam driven exciter generators. The exciters are often placed in separate rooms to preclude the possibility of their being involved in any accident in the main generating room.

Pumps and other auxiliaries that can be designed to run at high speed are now nearly always directly driven by turbines, and even low speed apparatus can now be geared to them. At the new 201st Street station in New York City there are fifteen small turbines driving the auxiliaries for three 15,000 K. W. main units. Draft fans are usually driven by direct acting steam engines, as the fans commonly used for forced draft purposes are generally run at variable speeds, which are unsuitable for turbines.

Turbine drives are now very largely used for boiler feed, and for hot well pumps.

With vertical types of turbines, the condenser pumps are commonly placed about the base of each main unit. This picture, taken at the Boston Elevated station, shows a circulating pump of the engine driven type. Circulating, hot well, and dry vacuum pumps are most frequently grouped about the condenser, which is directly underneath the turbine. Fig. 25 shows the dry vacuum pump at the Boston Elevated. Boiler feed pumps and practically all other auxiliary apparatus, excepting stoker engines, are kept out of the boiler room as much as possible, as they can thus be kept cleaner and maintained with fewer repairs.

The addition of superheat to high pressure steam has required the substitution of cast steel for cast iron fittings and valves in the main steam lines. The early plants where superheat was first installed had to learn this by hard experience and many re-built their pipe lines within a few years of their installation. Cast iron is not only weakened but is also distorted or distended by the extra heat. The valve seats and stems are now usually made of nickel steel, nickel bronze or "Monel" metal.

A matter that has received attention in some large stations, and will doubtless receive careful study in all of them, is the installation of permanent apparatus for weighing or measuring water used by turbines, and taking temperatures of steam and water, wherever these weights and temperatures can be of use, both in keeping the operating force posted on the day-to-day or even hour-to-hour economy of the station, and in making performance tests from time to time.

To have continuous boiler and turbine records of coal and water, that can at any moment be interpreted in terms of fuel economy, may not always be necessary but it is certainly desirable to have facilities ready to hand to get such information when it is wanted.

Reliable apparatus can be purchased, and installed at reasonable cost, which will enable the station engineer to keep in close touch with the performance of his equipment. The larger the station, the more necessary becomes this phase of the engineer's work.

There is such an infinite variety of detail possible in the arrangement of the electrical apparatus in a large central station that there is hardly time to do more here than call attention to a few of the salient points.

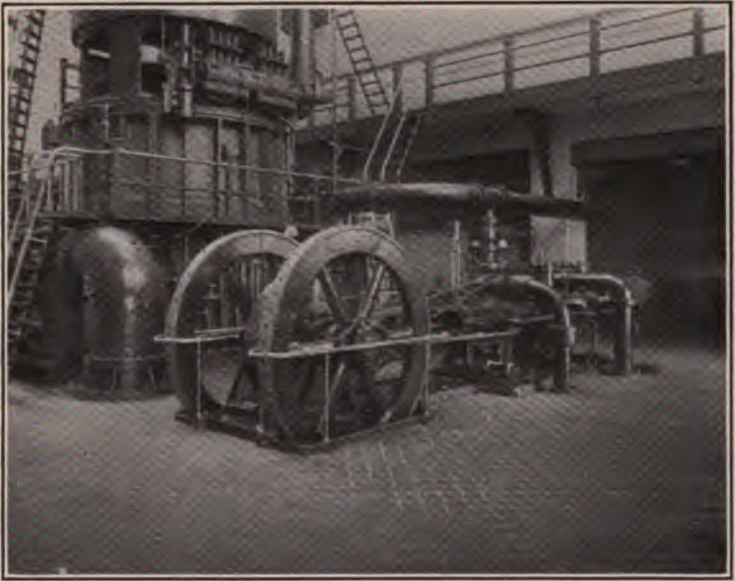


Fig. 25.—Dry Vacuum Pump, Boston Elevated.

Turbine driven generators are always of the revolving field type, and modern high speed machines are designed so compactly and with such economy of material as to require artificial ventilation in the armature, which is usually provided by large air ducts. In many cases these ducts bring air from outside of the Turbine Room, insuring cooler and cleaner air for ventilating the generator

coils. In the case of very large turbines, such as those at Chicago, these ducts are of themselves quite a feature of the Turbine Room.

The greatest amount of care and ingenuity about the electrical equipment of a central station is commonly expended on the switchboard installation.

It is only about fifteen years since the first designs were made for large oil switches in separate fireproof cells. This was first done on a large scale at the 96th Street Station of the Metropolitan Street Ry. in New York City, for engine driven generators of about 3,500 K. W. each. The great problem is to be able to cut off instantly and safely the flow of energy coming from a number of large generators feeding together on the same bus system, which may total anywhere between 30,000 to 100,000 K. W.

At time of short circuit or other serious disturbance on the system surges are built up momentarily to many times the normal amount of energy, and this enormous force usually concentrates at the oil switch when the latter is operated.

These problems have now been so well mastered, thanks to the untiring application of electrical engineers, that oil switches are now considered as reliable as the cables, armatures, and other apparatus which they are intended to protect.

Most of the stations we have been considering operate at from 6,600 to 15,000 volts. At the time that the big development in central stations began, twelve or fourteen years ago, 11,000 to 15,000 volts was about the maximum that cable manufacturers thought they could guarantee for regular service in underground power transmission. There have been only a few instances in this country where 20,000 volt cables have been installed, but the practice in Europe has tended to somewhat higher voltages for underground transmission, and has shown the practicability of it. There is no doubt but that in time the present power station transmission voltages for metropolitan districts will be doubled or trebled. The next step will probably see transmission cables and oil switches in city power stations operating at 20,000 to 25,000 volts.

At the South Boston Station the 6,600 volt turbine leads are connected to auto transformers for raising the pressure to 13,200 volts, thence to the bus bars which are enclosed in a structure of concrete, thence to the oil switches which are set in concrete apartments. Experience has shown the necessity in large stations

of very complete segregation of oil switches of both generators and feeders, for the sake of continuity of service.

These oil switches are all electrically operated through an auxiliary system of low pressure wiring worked from the exciter bus bars or a storage battery. Operation is by small contact switches on marble panels that take up very little space in comparison with the switches they operate. These switchboard panels are grouped in a relatively small room where they are within easy reach of the central operator and one or two assistants. The generator, feeder, and transmission line switches are often operated from separate benches or separate sets of panels.

The switchboard at the Waterside station in New York is arranged in a semi-circular form with apparatus both on the convex and concave faces. This switchboard is an impressive example of the extent to which space can be economized in the assembly of a large amount of indicating and control apparatus.

The electrical galleries are arranged in the Waterside stations in a typical manner. At this station the economy of space is all-important. The exciter battery is in the basement. The exciter generator is in the next gallery, the compartments containing the main bus bars on the third gallery, the automatic selector oil switches for generators and feeders on the next, the current and potential transformers on the fifth gallery, and another set of feeder oil switches at the top of the building.

The galleries run the whole length of the turbine room, but are not over 13 or 14 ft. wide, and the whole arrangement is of necessity very compact.

In the Northwest Station in Chicago there is very much more room available. Here the switching arrangements are located in a specially constructed house that is built separately for that purpose at one side of the main power station building.

A feature of the electrical equipment now attracting considerable attention is the employment of external reactance, either in the generator leads or between bus sections, or in the feeder leads. The percentage of reactance employed will depend both on the reactance of the generators and on that of the transmission system, and on the location chosen for the external reactance. To install these reactances in a station already congested is often a very difficult if not impossible problem; but in the large stations yet to be designed there is no doubt that provision will be made for installation of such reactances.

For general convenience and continuity of service a plan that now meets with general approbation is to divide the bus bars into sections with automatic oil switches and reactances between the sections.

In the recent Keokuk plant of 150,000 h. p. this plan is followed, there being three or four 9,000 K. V. A. generators per section, so that the amount of energy that could be forced into a short circuit is only a 20 or 25% of the whole station capacity.

The entire construction of the bus bar and switch compartment system is designed to be fireproof, and all bus bars and other live parts in the main circuits are carefully protected from outside contact of all kinds. The effect of a possible explosion in an oil switch is thoroughly safeguarded and it is customary to place all apparatus containing insulating oil in separate fireproof compartments.

In very large stations it is also necessary to provide suitable means for testing and calibrating the electrical indicating and recording switchboard instruments without interrupting the service. A great deal depends upon meter indications in respect to checking up the economic performance of the stations as well as of the individual units, and the testing equipment for such purposes runs into considerable detail.

The developments of the past few years in central station engineering have been rapid. Mr. Abbott, chief engineer of the Commonwealth Edison Company, in a paper read about a year ago, stated that between the time that the plans for the Northwest Station were made and the time that the station was placed in operation, as great strides had been made as at any period of equal length in the history of the art; that the equipment then going into the extension of the Fisk Street Station would eclipse the performance of the newly built Northwest Station; and that the future equipment of the latter would differ from the original equipment and would probably show an improvement over that now going into the Fisk Street Station.

It is somewhat encouraging to engineers to feel that further progress in economy is possible, though the steps get shorter as the limits are approached.

Dr. Ferranti, the famous pioneer in electrical engineering, who first proposed and used large direct connected alternators in London, 25 years ago, is making further developments in steam

turbine economy. He has actually built and operated an experimental turbo-generator of 3,000 K. W. capacity, which has produced current at the rate of 1 K. W. hour on 9.4 lbs. of steam. This economy, which is about one-sixth better than the highest guarantees recently made by turbine manufacturers, is obtained chiefly by the use of superheat, the steam being withdrawn from the turbine when about halfway through it and superheated again before finishing its expansion through the turbine. If such an economic performance can be obtained commercially it would seem to establish the supremacy of the steam turbine as a prime mover for many years to come.

In conclusion, we can sum up by saying that the requirements of capacity and reliability are fully met in modern central stations. Further economy is being sought by operating men through the employment of greater skill and more refinements in the combustion of coal and on the part of constructors and manufacturers by the use of higher superheat and lower vacuum for turbine operation.

Free exchange of information between engineers, always desirable, is especially so among these whose duty it is to conserve the sources of power for the benefit of humanity; and every engineer who makes available the results of some advance in central station economy renders a lasting service to the community, and raises the standard of engineering achievement.

WALLACE B. RIEGNER

Wallace B. Riegner was born in Strasburg, Franklin Co., Pa., Jan. 27, 1854. In 1867 the family removed to Chambersburg, Pa., and here Mr. Riegner grew to manhood. After graduating from the Chambersburg High School and the Chambersburg Academy he entered Lafayette College, from which he was graduated with honor in 1877. One year after this was spent as teacher of drawing in the High School in the city of Reading, Pa. Several years later Mr. Riegner entered the employ of the Reading R. R. Co., which connection remained uninterrupted until his death.

Mr. Riegner was a member of Zion's Reformed Church in Chambersburg. He died in Chambersburg, Jan. 19, 1914, in the 60th year of his age.

CHARLES W. CLOSE

Charles W. Close, real estate agent in South Philadelphia, died on Saturday, February 7th, at his home, 1313 South Broad street. Mr. Close had been suffering for more than a year from a complication of diseases. He was sixty-five years old.

Mr. Close attended the public schools and later was graduated from the Engineering Department of one of the extinct technical schools of this city. He was surveyor in the old district of Southwark, succeeding his father, who was appointed in 1848, serving until January 1, 1907.

In 1862, Mr. Close's father was one of the founders of the real estate firm of Close & Chubb, and since that time the organization has enjoyed an enviable career.

Mr. Close is survived by two sisters, Mrs. Joseph C. Moore and Mrs. Fulton F. Peale. He was a member of the Engineers' Club, Franklin Institute and the Melita Lodge of Masons.

ABSTRACT OF MINUTES OF THE CLUB

Regular Meeting, January 3, 1914

The meeting was called to order by President Taylor at 8.30 p. m., with 41 members and visitors in attendance.

Mr. Eli T. Conner presented the paper of the evening, entitled "The Scranton Mine Cave Problem," which was discussed by Messrs. H. M. Chance, John C. Trautwine, Jr., E. M. Nichols, and others.

It was unfortunate that the inclement weather kept the attendance down, as Mr. Conner's paper was extremely interesting and instructive.

Joint Meeting of the Engineers' Club and the Philadelphia Chapter of the American Society of Mechanical Engineers, January 17, 1914

The meeting was called to order by President Taylor at 8.20 p. m., with 172 members and visitors in attendance. The Secretary announced that the Board of Governors, at their Regular Meeting on January 15, 1914, had elected the following to membership: Active, Walter Swain Nichols; Junior, Joel S. Harris and Edward T. Peters.

The President then relinquished the chair to Mr. D. Robert Yarnall, Chairman of the Philadelphia Chapter of the American Society of Mechanical Engineers.

Mr. Yarnall introduced Mr. George R. Henderson as the speaker of the evening. Mr. Henderson presented a paper entitled, "Recent Improvement in Steam Locomotives," which was discussed by Messrs. C. H. Bigelow, William Forsythe, Walter Loring Webb, Harold Goodwin, Jr., J. E. Fulweiler, and J. P. Mudd.

At the conclusion, a unanimous vote of thanks was tendered Mr. Henderson.

Thirty-fifth Annual Meeting, February 7, 1914

The meeting was called to order by President Taylor at 8.40 p. m., with 77 members and visitors in attendance.

The President presented the annual report of the Board of Governors, stating that the same had been unanimously approved by the Board at a special meeting held on February 7th. On motion the report of the Board was unanimously approved and ordered filed.

The paper of the evening was the annual address by the President, in which were presented some new and interesting facts, illustrated by diagrams, of the development of the Club from the time of its inception.

The President then presented a paper on the Street Cleaning Problem in Philadelphia, illustrated with lantern slides, and depicting the intricate problems to be solved in placing this part of the municipal work on a scientific basis.

The Secretary presented the report of the tellers of the election of officers, which was unanimously approved as follows: President, S. M. Swaab; Vice

President, J. A. Vogleson; Secretary, Henry L. McMillan; Treasurer, J. Reese Bailey; Directors, J. H. M. Andrews, E. J. Dauner, Fred C. Dunlap, Henry Hess.

President Taylor then turned over the Chair to President-elect Swaab, who made a short address setting forth his conception of the work to be done by the new officers.

Business Meeting, February 21, 1914

Meeting was called to order by Vice President Mebus, with 71 members and visitors in attendance.

Mr. Mebus announced he had received a letter from Mr. Swaab stating that he was progressing satisfactorily and was looking forward to the time when he could resume his active duties.

The Secretary announced that Messrs. H. V. Atkinson, Geo. A. Eagan, and Wm. C. H. Slagle had been elected to active membership by the Board of Governors at their regular meeting, held February 16, 1914.

Petitions, each signed by twenty-five active members, were received, proposing Col. George W. Goethals and Benj. Smith Lyman for Honorary Membership.

Prof. Arthur W. Goodspeed, Prof. of Physics, University of Pennsylvania, delivered a lecture on "Radioactivity with Special Reference to Radium."

The discussion was participated in by Messrs. Nichols, Hering, and Hagy, and Dr. Newcompe. A unanimous vote of thanks was extended Professor Goodspeed.

Regular Meeting, March 7, 1914

The meeting was called to order by Past President Hess, at 8.35 p. m., with 123 visitors and members in attendance. The minutes of the business meeting held Saturday, February 21, 1914, were approved as printed in abstract.

The Secretary called attention to the Joint Meeting of the Club and the American Society of Mechanical Engineers to be held Saturday, March 14, 1914; also to the meeting and smoker of the Scientific and Engineering Societies of Philadelphia on Friday, May 15, 1914, at 8 p. m., at the Continental Hotel.

Mr. G. J. Ray, chief engineer of the D. L. & W. R. R., presented the paper of the evening, entitled "The Rebuilding of Forty Miles of the Lackawanna Main Line," which was discussed by Messrs. Hess, McManus, Webb, Cheyney, Develin, Stier, and Dr. Chance.

A unanimous vote of thanks was extended Mr. Ray.

Joint Meeting of the Engineers' Club and the American Society of Mechanical Engineers, March 14, 1914

The meeting was called to order by Vice President Mebus at 8.30 p. m., with 211 members and visitors in attendance. Mr. Mebus relinquished the chair to Mr. D. Robert Yarnall, Chairman of the Philadelphia Section of the American Society of Mechanical Engineers, who introduced Mr. I. E. Moultrop, Assistant Superintendent of the Boston Edison Illuminating Company, as the speaker of the evening. Mr. Moultrop read a paper, entitled "The Development of the

Modern Electric Supply Station," which was discussed by Messrs. W. C. L. Eglin, A. C. Wood, W. C. Kerr, and Thomas C. McBride.

A unanimous vote of thanks was tendered Mr. Moultrop.

REGULAR MEETING, MARCH 21, 1914

The meeting was called to order by Vice President Mebus at 8.30 p. m., with 67 members and visitors in attendance.

Mr. John Birkinbine presented the paper of the evening, entitled "A Hydro-Electric Development on the Tallulah River, Georgia," which was discussed by Messrs. J. C. Wilson, John C. Trautwine, Jr., E. U. Gibbs, and Drs. Hering and Chance.

ABSTRACT OF MINUTES OF THE BOARD

Regular Meeting, January 15, 1914

Present: President Taylor, Vice Presidents Plack and Swaab, Directors Hess, Gilpin, Haldeman, Furber, Yarnall, Gibson, Hibbs, the Secretary, and the Treasurer.

The following resolution, with reference to the limitation of house charges, was passed:

"That any member who regularly lives at the house and uses the restaurant, and has a three months' record of taking care of his indebtedness, may have the amount of his restaurant credit raised to $100, and that in order to take care of those rare cases when a member, heretofore in good standing, suddenly greatly increases his indebtedness, the Business Manager be directed to refer the matter to the House Committee for its decision."

The following resignations were read and accepted as of December 31, 1913: J. C. Bartlett, Lewis B. Luders, G. Wise, W. E. Dodds, E. T. Wilkinson, F. S. Crispin, Harrison W. Latta, Nathan Shute, Amos C. Fisler, Clarence W. Rodman, S. S. Evans, F. C. Andrews, Wm. H. T. Thornhill, Chauncey G. Helick, Horace E. Rice, Josiah Dow, John C. Graf, Horace C. Dickey, Carl P. Nachod, Walter D. Banes, Samuel Sinclair, Jr.

The Treasurer reported that the Annual Financial Report was not yet complete, but would be ready within the course of a week.

The Library Committee's report was presented, and after considerable discussion was referred back to the Committee, in order that the plans may have the furniture that will be placed in the rooms plotted on them, that the Board might study the rearrangement of the room to better advantage.

The House Committee's report was presented and the Committee was instructed by the Board to receive bids and award the contract for placing a first class slag roof on the building.

The Membership Committee's report was presented and approved, and, on motion, the following were elected to membership: Active, Walter Swain Nichols; Junior, Edward T. Peters, Joel S. Harris.

Reports of the Publication and Publicity Committees were presented.

The Business Manager's report was read and approved.

A communication from C. Burke Filbert in reference to transference to non-resident membership was presented and the Treasurer authorized to place him in the non-resident membership class as of January 1, 1914.

The President appointed the following Committee to take up the question of charge for the meeting room, to consider all the phases of it, and to make a report to the Board at its next meeting, if possible: S. M. Swaab, Chairman, J. E. Gibson, Henry Hess, F. K. Worley.

The meeting adjourned at 11.05 p. m., to meet again at the call of the chair for the purpose of ratifying the annual report.

Adjourned Meeting, February 7, 1914

The Annual Report of the Board of Governors, as printed, was, on motion, unanimously approved.

ORGANIZATION MEETING, FEBRUARY 16, 1914

Present: Vice Presidents Mebus and Vogleson, Directors Haldeman, Furber, Yarnall, Hibbs, Worley, Andrews, Dauner, Dunlap, Hess, Gibson, and the Secretary.

Mr. H. Clyde Snook was unanimously elected Vice President to fill the unexpired term of Mr. S. M. Swaab, term to expire February, 1916.

Mr. Joseph C. Wagner was unanimously elected Director to fill the vacancy caused by the election of Mr. Snook to the Vice Presidency, term to expire February, 1916.

The President announced that the following standing Committees had been appointed for the year 1914:

Finance.—J. A. Vogleson, Henry Hess, J. Reese Bailey, James Mapes Dodge, Coleman Seller, Jr.

House—F. K. Worley, J. A. Vogleson, E. F. Cobb, J. H. M. Andrews, George S. Cheyney.

Membership.—J. E. Gibson, F. C. Dunlap, Charles F. Mebus, Henry A Moore, H. F. Sanville.

Meetings.—B. A. Haldeman, W. C. Furber, D. Robert Yarnall, W. P. Taylor, Robert B. Owens.

Publication.—Manton E. Hibbs, J. E. Gibson, H. Clyde Snook, Richard Gilpin, John C. Trautwine, 3d.

Library.—F. C. Dunlap, H. C. Berry, E. J. Dauner, F. N. Morton, Charles F. Puff, Jr.

Publicity.—D. Robert Yarnall, Henry Hess, J. H. M. Andrews, George T. Gwilliam, W. P. Taylor.

REGULAR MEETING, FEBRUARY 16, 1914

Present: Vice Presidents Mebus and Vogleson, Directors Haldeman, Furber, Yarnall, Hibbs, Worley, Andrews, Dauner, Dunlap, Hess, Gibson, and the Secretary.

The minutes of the Regular Meeting of January 15th and the Adjourned Meeting of February 7th were read and approved.

The President recommended that a Committee on Revisions of By-Laws be authorized, and after this was done, he appointed the following members to constitute that Committee: H. E. Ehlers, D. Robert Yarnall, F. C. Dunlap, John C. Trautwine, Jr., Erskine Hazard.

The Public Relations Committee was also authorized and the President appointed the following members to constitute the Committee: Henry Leffmann, Robert H. Fernald, James Mapes Dodge, S. M. Vauclain, Coleman Sellers, Jr., Henry Hess, Edgar Marburg, Walton Clark, W. P. Taylor, John C. Trautwine, Jr., John Birkinbine, Carl Hering, H. M. Chance, Thomas C. McBride, Joseph C. Wagner, George T. Gwilliam, William S. Twining.

The Board elected the following Tellers and Alternate Tellers for the year 1914: Tellers, L. H. Kenney, John S. Ely, John Horridge; Alternate Tellers, Moriz Bernstein, Chas F. Puff, Jr., H. P. Gant.

A resolution, properly endorsed, was presented to the Board of Governors, suggesting that Benjamin Smith Lyman be elected to Honorary membership,

and the Secretary was instructed to proceed in the legal manner, in order that this might be done.

It was moved and carried that one of the regular meetings each month of the Engineers' Club of Philadelphia be a joint meeting, under the auspices of the Engineers' Club of Philadelphia and the local branch of one of the national engineering societies.

It was also moved and carried that five voting members, the members of the Finance Committee, and the Chairman of the Membership Committee be appointed to constitute a Committee for the Increase of Membership, to study the local field of engineers with the object of seeing how many might be obtained for membership in the Engineers' Club and to recommend the annual dues that might be charged in the event of obtaining these members.

The resignations of Theodore W. Pinard and Barclay White were presented and the Secretary instructed to notify them that these resignations could not be accepted until the dues had been paid, or until they had presented a request for the remittance of the dues of 1914.

The resignations of Mr. Herbert L. Towle and Mr. Otto W. Schaum were read and accepted.

Upon recommendation of the Membership Committee, the following were elected to Active membership: Harry V. Atkinson, George Arthur Eagan, and William C. H. Slagle.

Messrs. Hess, Gibson, and Worley were appointed a Committee to recommend to the Board at their next meeting a list of charges to be made for the use of the meeting room and for Committee meetings.

The following resolution was passed:

"That the speaker of the evening and guests specially invited, not members of the Engineers' Club of Philadelphia, be each sent a formal invitation to be the guests of the Club's Officers at dinner preceding the meeting."

Mr. T. Hugh Boorman was reinstated to membership as of November 14, 1912.

The death of Mr. Wallace B. Riegner on January 19, 1914, was announced, and the Treasurer authorized to strike his dues for the year 1914 from the books. The death of Mr. Charles W. Close on February 7, 1914, was also announced, and the Publication Committee instructed to prepare memoriams to be published in the April Proceedings.

Appropriation of $100 for the February and March Club nights and $200 for Ladies' Night was made to the House Committee.

The following resolution was passed:

"That ways and means be considered for collecting results of borings and, if possible, specimens for exhibition in the Engineers' Club of Philadelphia."

The matter was referred to the Library Committee.

The Secretary was also instructed to communicate with the members of the Board of Governors to ascertain the most convenient time for holding the meetings of the Board.

Regular Meeting, March 17, 1914

Present: Vice Presidents Mebus and Vogleson, Directors Berry, Yarnall, Hibbs, Wagner, Worley, Andrews, Dunlap, Hess, the Secretary, and the Treasurer.

The minutes of the Regular Meeting of February 16th were read and approved.

Mr. H. P. Childs was transferred to non-resident membership as of January 1, 1914, and the Treasurer authorized to make the proper corrections in his books and render Mr. Childs corrected statement.

The resignations of F. R. Pleasonton and John L. Curtiss were read and accepted.

The Treasurer reported a net gain of $17.55 to March 1st.

Reports of the House, Publication, and Library Committees were read and approved.

Report of the Membership Committee was presented and the following were elected: To Active Membership, Albert T. Goldbeck; to Junior Membership, Clotworthy Birnie, Jr.

Appropriation of $25 was made to the Library Committee for the purpose of purchasing an Atlas of the City of Philadelphia.

The Committee on Increase of Membership presented its report and the following resolution was adopted:

Resolved, That the present Committee on Increase of Membership be authorized to represent the Board of Governors and speak for it in the meetings that will be brought about to carry out the plan to establish a federation of the local technical societies.

The following resolution was also adopted:

Resolved, That it is the sense of the Board of Governors of the Engineers' Club of Philadelphia that the plan as outlined by the Chairman of the Committee on Increase of Membership is extremely desirable, and meets with the approval of this Board.

It was moved and carried that the Committee on Increase of Membership be authorized to send out the prospectus which it presented to the Board, in its present form, or in such modified form as the Committee may determine.

The Committee on rent of meeting room presented its report, and, after discussion, the following rate was adopted: Use of meeting room, $10. Use of lantern, $3.

The Secretary was instructed to canvass the Board, in accordance with the By-Laws, in order to elect Colonel George W. Goethals and Mr. Benjamin Smith Lyman to Honorary Membership.

The Tuesday evening before the second regular meeting in the month was unanimously selected as the regular meeting night for the Board of Governors.

ANNUAL REPORT OF THE BOARD OF GOVERNORS

For the Fiscal Year 1913

January 15, 1914.

The following report was submitted to the Board of Governors at a Special Meeting held January 27th, 1914, and as no quorum was present, it was ordered to be printed subject to approval by the Board of Governors at a special meeting to be held prior to the Annual Meeting.

To the Members of the Engineers' Club of Philadelphia:

The Board of Governors herewith presents its report for the year ending December 31, 1913, as follows:

Eighteen stated meetings of the Club were held, at which the maximum attendance was 173 and the average 99. Ten regular and two special meetings of the Board of Governors were held.

The summary of membership on December 31, 1913, as compared with the summary of December 31, 1912, is as follows:

	1912			1913		
Class	Resident	Non-Resident	Total	Resident	Non-Resident	Total
Honorary	1	2	3	1	1	2
Active	351	107	458	340	113	453
Associate	61	7	68	63	10	73
Junior	61	9	70	54	11	65
	474	125	599	458	135	593

Thirty-four Active, fifteen Associate, and fifteen Junior Members were elected; one Associate Member was transferred to the Active grade, seven Juniors to the Active grade, and four Juniors to the Associate grade; three Active, one Associate, and one Honorary Member died; thirty-four Active, six Associate, and seven Junior Members resigned; twelve Active, six Associate, and three Junior Members were dropped from the rolls; two Active and one Junior Member were reinstated to membership.

The record of deaths is:

Eugene E. Dunlap, Active Member, died January 16, 1913.
John Fritz, Honorary Member, died February 13, 1913.
Frank Burns, Active Member, died March 11, 1913.
Walter J. Warner, Associate Member, died June 10, 1913.
R. A. Shillingford, Active Member, died June 16, 1913.

The financial condition of the Club is better than it has ever been, the net gain being $2,671.41, as compared with $1,625.71 for the year 1912. The accounts receivable on the books at the end of the year are practically all good.

During the year the following liabilities were reduced: Building Fund notes from $8,100.00 to $7,950.00; the contribution from the Junior Section of $203.49 was expended in purchasing books for the library.

The Annual Reception and Dance, which proved to be the most successful in the Club's history, was held on May 7th, 1913. The Board, early in the fall of last year, decided to give Smokers monthly. Three have thus far been given with much success, and the Board feels that the monthly Smokers should be continued.

The following organizations have been holding meetings in the Club-house, and it is hoped the Club-house may become the center of activities of the technical organizations of the city:

Society of Municipal Engineers.

American Society of Marine Draftsmen, Delaware River Branch.

American Chemical Society, Philadelphia Chapter.

American Institute of Electrical Engineers, Philadelphia Section.

Illuminating Engineering Society.

American Society for Testing Materials.

The following papers were presented during the year:

January 4.—"Wise Utilization of the Water Resources of Pennsylvania." Morris Knowles.

January 18.—"The Engineer's Interest in Public Land Questions." Dr. George Otis Smith, Director, U. S. Geological Survey.

February 1.—Annual Address, President Henry Hess.

February 15.—"The Unwritten Law." Manton E. Hibbs.

March 1.—"The Sinking and Lining of Shafts." Francis Donaldson, Chief Engineer, T. A. Gillespie Company, New York.

March 15.—"The Design and Construction of the Hydro-Electric Plant at Estacada, Oregon." Hermann V. Schreiber.

April 5.—"The Panama Canal As It Relates to the Treaties." Rear-Admiral C. M. Chester, U. S. N., retired.

April 19.—"The High Pressure Fire Service." John E. Codman.

May 3.—"Some Aspects of the Subject of Transportation." Lt. Col. J. E. Kuhn, U. S. A., Corps of Engineers.

May 17.—"Suction Gas Producer Pumping Engine vs. Compound Condensing Corliss Crank and Fly Wheel Pumping Engine, Giving Cost of Operation and Fixed Charges Based Upon Five Years' Operating Experience." J. E. Gibson and S. H. Wright.

June 7.—"Scientific Management Applied to the Design and Management of a Modern Valve Plant." D. Robert Yarnall.

September 20.—"Sewage Treatment in Pennsylvania." Charles F. Mebus.

October 4.—"The Limitations of Mathematical Theory Applied to Engineering." W. G. Button.

October 18.—"Modern Color Photography." Henry Leffmann.

November 1.—"Colossal Waste Due to Bad Municipal Engineering." Bernard J. Newman, Secretary Philadelphia Housing Commission.

November 15.—"The Grand Central Terminal Improvements." Geo. A. Harwood, Chief Engineer, N. Y. C. & H. R. Railroad.

December 6.—"The Hudson River Crossing of the Catskill Aqueduct." Ralph N. Wheeler, Division Engineer, Board of Water Supply, New York.

December 20.—"Concrete Roadways." Lewis R. Ferguson, Assistant Secretary, American Portland Cement Manufacturers.

Financial Report for the Year 1913.

Statement of Assets and Liabilities

as of December 31, 1913.

Assets

Cash—Colonial Trust Co.—Active Account	$ 778.84	
Colonial Trust Co.—Interest Account	1802.50	
In Office	385.45	
		$ 2966.79
Accounts Receivable		2937.48
*Building Fund Notes, special fund	$ 3250.00	
*Second Mortgage Bonds, special fund	200.00	
		3450.00
*Sinking Fund for Redemption of Second Mortgage Bonds:		
Regular Account	$ 37.23	
Interest Account, special fund	92.59	
Principal Account, special fund	182.44	
		312.26

*In hands of the Trustees for the Redemption Fund of 2d Mortgage Bonds.

Inventory of Supplies on Hand

Wines and Liquors	$ 274.19	
Restaurant Provisions	100.15	
Cigars	239.32	
House Supplies	62.93	
	$ 676.59	
Fuel	32.48	
		709.07

Property

Building No. 1317 Spruce Street	$72,850.00	
Furniture and Fixtures—House	9,172.95	
Furniture and Fixtures—Restaurant	1,421.28	
Library	2,100.00	
		85,544.23

Insurance

Perpetual on Club-house	$ 1,611.66	
Employer's Liability	29.16	
		1,640.82

Miscellaneous

J. Reese Bailey, Treasurer		73.
Total Assets		$97,

Liabilities

Accounts Payable		$ 3,583.54
Bills Payable, Building Account		7,950.00
Trustees for the Redemption Fund of Second Mortgage Bonds:		
Note, special fund	$ 3,250.00	
Second Mortgage Bonds, special fund	200.00	
		3,450.00
First Mortgage Payable	$40,000.00	
Second Mortgage Bonds	25,250.00	
		65,250.00
Accrued Interest—First Mortgage	$ 1,080.00	
Accrued Interest—Second Mortgage Bonds	1,802.50	
Accrued Interest—Building Fund Notes	150.47	
		3,032.97
Appropriation from Junior Section to Library Committee		.68
Library Fund		10.00
Link Belt Co., 2d Mortgage Bond Account		178.35
Total Liabilities		$83,455.54

Capital (Surplus) Account

Surplus, January 1, 1913		$ 12,647.54	
Adjustment of Perpetual Insurance	$ 178.20		
Balance of Manager's Salary for 1912	200.00		
Suspense Account, Uncollectable Accounts	953.27		
		1,331.47	
		$11,316.07	
Reserve for 2d Mortgage Bonds	$ 36.20		
Unexpected Returns	155.00		
		191.20	
		$11,507.27	
Gain for 1913, as per Statement of Income and Expense		2,671.41	
Surplus as of December 31, 1913			$14,178.68
			$97,634.22

STATEMENT OF INCOME AND EXPENSES FOR THE YEAR 1913

INCOME

Dues—Net	$16,515.00	
Initiation Fees	1,470.00	
		$17,985.00

Publications

Advertising—Directory		$ 390.00	
Advertising—Proceedings		627.55	
Sales—Directory		1.00	
Sales—Proceedings		73.43	
			1,091.

Miscellaneous

Badge Sales		$ 18.25	
Interest on Deposits, Active Account	$ 28.11		
Interest on Deposits, Interest Account	9.36		
Interest on Sinking Funds	9.17		
Interest on Building Fund Notes, special fund	79.89		
Special fund	10.00		
		136.53	
Telephone Receipts		136.41	
			291.

Club-house Business

Billiard and Pool Sales		$ 260.40	
Cigar Sales		2,272.46	
Lodging		3,687.44	
Rent of Meeting Room		623.00	
Restaurant Sales		6,991.50	
Restaurant Sales, Meals of Employees		2,232.00	
Wine Sales		1,305.58	17372.
Total Income			$36,740.

EXPENSE

Salaries and Wages

Manager		$ 2,100.00	
House, Salaries and Wages	$2,560.32		
House, Meals of Employees	720.00		
		3,280.32	
Office, Salaries	$1,919.72		
Office, Meals of Employees	432.00		
		2,351.72	
Restaurant, Salaries and Wages	$2,896.46		
Restaurant, Meals of Employees	1,080.00		
		3,976.46	
			$11,708.

Expense

House Expense		$ 1,147.37	
Office Expense		642.93	
Directors' Expense		30.00	
Library Expense		61.30	
			1,881.

Publications

Directory Publishing		$ 315.94	
Proceedings Publishing		1,169.72	
			1,485.66

Miscellaneous

Badge Purchases		$ 11.00	
By-Laws Revision		140.90	
Club Lucheons		360.00	
Entertainment Committee, New Year's Day	$ 38.33		
Entertainment Committee, Reception	229.53		
Entertainment Committee, Smoker	150.00		
		417.86	
Excess and Deficiency Account		1.05	
Extraordinary Expense, House Account		354.08	
Fuel Purchases	$ 454.12		
Inventory, January 1, 1913	26.12		
	$ 480.24		
Inventory, December 31, 1913	32.48		
		447.76	
Gas and Electricity		1,286.03	
Insurance Expense		65.58	
Meetings Committee		433.60	
Membership Committee		75.65	
Nominations Committee		9.20	
State Tax on Second Mortgage Bonds		101.00	
Taxes and Water Rent		943.00	
Telephone Expense		389.21	
Trustees of Sinking Fund		3.00	
			5,038.92

Interest

Interest on First Mortgage	$ 2,160.00	
Interest on Second Mortgage Bonds	1,262.50	
Interest on Building Fund Notes	422.86	
		3,845.36

Club-house Business

Billiards and Pool Purchases	$ 8.90	
Cigar Purchases	1,990.53	
Wine Purchases	1,099.57	
		$3,099.00
Restaurant Expense	$ 873.69	
Restaurant Provision Purchases	6,177.65	
		7,051.34
		$10,150.34

Inventory, December 31, 1913

Cigars	$239.32			
Restaurant Provisions	100.15			
House Supplies	62.93			
Wines and Liquors	274.19			
		$676.59		

Inventory, January 1, 1913

Cigars	$174.15			
Restaurant Provisions	143.40			
House Supplies	50.43			
Wines and Liquors	267.37			
		$635.35		
Deduct Increase in Inventory			41.24	
Expense of Club House Business				10,109.10
Total Expenses				$34,069.14
Net Gain for 1913				2,671.41
				$36,740.55

Respectfully submitted,

J. R. BAILEY, Treasurer.

Audited and found correct.

STOCKTON BATES, C.P.A., For Stockton Bates & Sons.

The following is the report of the Trustees of the Bond Redemption Fund:

SIXTH ANNUAL REPORT OF THE TRUSTEES OF THE BOND REDEMPTION FUND

Being a Statement of Business for the Year 1913

1913.	*Receipts*		
February 17, Coupons Cashed	$ 10.00		
February 17, Interest on Notes	79.89		
February 28, Balance returned by Club	36.20		
February 28, Instalments	177.00		
December 31, Interest on Deposits	9.17		
		$	312.26

Expenditures (None)

Balance, December 31, 1913	$	312.26

The Trustees hold the following negotiable securities:

Note of the Engineers' Club to Trustees of Bond Redemption Fund for $3,250.00

Two second mortgage bonds, Nos. 51 and 52, for $100.00 each.

The cash balance is deposited with the Western Saving Fund Society.

HENRY LEFFMANN
EDWIN F. SMITH
EDGAR MARBURG, *Trustees.*

Respectfully submitted,

THE BOARD OF GOVERNORS,
W. P. TAYLOR, *President*
EDW. E. KRAUSS, *Secretary.*

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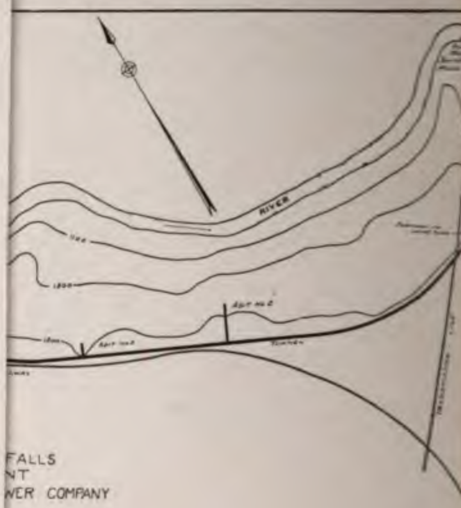

FALLS
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WER COMPANY

CROSS SECTION OF TUNNEL

Editors of other technical journals are invited to reprint articles from this journal, provided due credit be given the PROCEEDINGS

PROCEEDINGS

OF

THE ENGINEERS' CLUB

OF PHILADELPHIA.

ORGANIZED DECEMBER 17, 1877. INCORPORATED JUNE 9, 1892.

NOTE—The Club, as a body, is not responsible for the statements and opinions advanced in its publications.

Vol. XXXI JULY, 1914. No. 3

PAPER NO. 1138

HYDRO-ELECTRIC DEVELOPMENT ON THE TALLULAH RIVER, GEORGIA

By JOHN BIRKINBINE

Read March 21, 1914

Few districts offer better opportunities for generating electricity by the potentiality of falling water, and not many have the possibilities more liberally developed than the territory recognized as the Southern-Appalachian-Piedmont Region.

The chain of mountains extending southwest through the Virginias, the Carolinas, Georgia, and Tennessee, with crests from 2,000 to 6,000 feet above sea level and slopes generally forest covered, although denuded of much of the best timber, offer the first obstruction to the moisture-laden winds wafted westward from the Atlantic Ocean. Hence, the rainfall is liberal, the stream flows, considering the steep slopes, well maintained, and numerous favorable sites for hydro-electric installations have been improved while others await development.

This Piedmont region is grid-ironed by transmission lines, with poles or towers as frequent reminders of a general distribution of electrical energy to cities, towns and villages whose existence is dependent upon hundreds of cotton mills well lighted and some

electrically operated, although by smoke clouds issuing from tall chimneys a number indicate continued reliance upon steam.

The plant described in the following pages is the generating feature of a system of electric supply which being inter-connected with others permits of delivering current fully 400 miles from a generating station, while the extreme limits of connected system approximate 600 miles. This statement is not to be accepted as asserting that current *is* carried these distances for use, but that the number of plants, and the extent of their inter-connecting feeding lines, would in emergency permit of such transmission.

The Georgia Railway & Power Company resulted from consolidations of a number of plants and franchises, including the lighting and transportation systems of the cities of Atlanta and Rome, Georgia, and other municipalities, its latest addition being the recently completed hydro-electric plant at Tallulah Falls as the culmination of a project suggested by W. A. Carlisle, an engineer who years ago scouted through the gorges and defiles of the Appalachian Range seeking available water power sites, but the present improvement is on a greater scale than that suggested by Mr. Carlisle.

The installation recently put into service and which is herein described was planned by and carried out under the direction of Mr. Chas. O. Lenz, of New York, as chief engineer, with Mr. Eugene Lauchli in special charge of hydraulic construction. My familiarity with details being due to association in an advisory capacity in hydraulic features, requiring frequent visits to Tallulah Falls and vicinity. The description will hence be mainly confined to some details of the hydraulic installation, leaving the electrical equipment to others.

The construction was carried on by a subsidiary organization, the Northern Contracting Company, with Mr. Chas. G. Adsit, as engineer, directing the operations through subordinates in charge of special features.

The Tallulah River

Has its source and course in the mountains of Northwestern Georgia, close to the boundaries of that State with those of North and South Carolina and Tennessee. Rising at an altitude of 3,000 feet the river winds about mountains in a general southeasterly course for 40 miles, and joining the Chatooga forms the

Tugalo river about elevation 750 feet. The Tugalo river defines a portion of the boundary between South Carolina and Georgia, ultimately reaching the ocean through the Savannah river.

The Tallulah river, three miles above its confluence with the Tugalo river, flows through a gorge or cañon known as "Tallulah Falls," and in the distance of 1½ miles drops 500 feet by seven successive falls, aggregating 300 feet with intervening rapids, the sides of the gorge being so steep that it is only possible to reach the stream bed at a few points by difficult trail. The scenic fea-

FIG. 1.—Tallulah Falls Dam. View looking up stream, showing the rollway with lower temporary sluiceways discharging stream flow. Openings for sealing the latter with concrete are also indicated.

tures are therefore unusually impressive. The drainage area of the river above Tallulah Falls is 191 square miles, the average annual rainfall on which approximates 70 inches

The development of this power by the Georgia Railway & Power Company has caused persistent opposition from parties who preferred preserving the natural beauties of the gorge to the utilization of its power and the distribution of this at a saving of 220,000 tons of coal annually.

There will always be some water in the gorge, and the rugged massive rock faces, protruding from verdure clad slopes, extending downwards hundreds of feet will not be destroyed or marred, but ordinarily the picturesque falls and the music of falling water in volume will be missing, their potential energy being utilized through 240 miles of high tension transmission to substations for distribution over feeder lines.

FIG. 2.—Tallulah Falls Dam completed to crest, with water in pool discharging through temporary sluiceways and one permanent sluice gate shown. Piers for carrying roadway in course of erection.

THE HYDRO-ELECTRIC IMPROVEMENT

Consists of a concrete dam 110 feet high, closing the gorge at a narrow point and forming a pool which backs water for about a mile up the river. Intake chambers, provided with gates and trash racks, admit water from this pool to a pressure tunnel 6,663 feet long, terminating in a surge tank or forebay, from which steel penstocks lead to five turbine wheels operating under 600 feet head directly connected by vertical shafts to generators, each of 10,000 K.W., nominal capacity.

There is also under construction, six miles above Tallulah Falls dam, a storage reservoir, which when completed can impound in a lake, $9\frac{1}{2}$ miles long, 1,340 million cubic feet of water available for regulating the flow of the stream. The fall of 100 feet

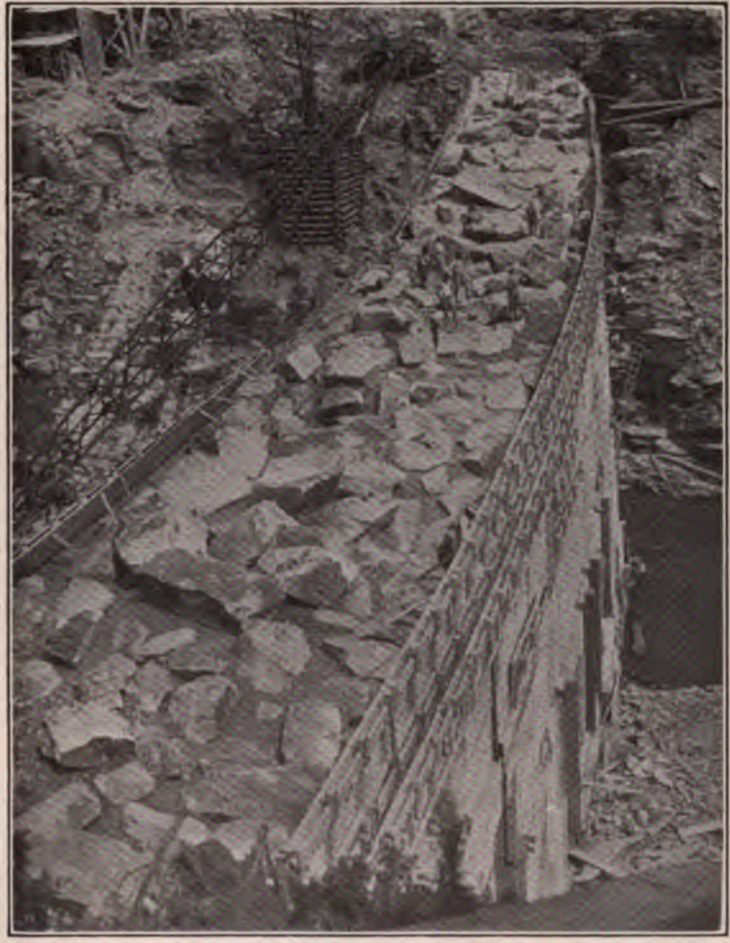


FIG. 3.—Tallulah Falls Dam. Top view of cyclopean masonry showing the liberal proportions of "plums" in concrete.

created by the hollow reinforced concrete dam forming this storage reservoir will ultimately be utilized to generate electricity, which can be conveyed to the switch-house of the main power

station by a transmission line three miles in length over the mountain.

A feature of the construction is a transmission line 88 miles in length, consisting of a series of steel towers carrying six lines of 0000 copper wires, and terminating at the largest open air substation in existence. From this, branch transmission lines with similar towers, supporting 00 copper wires, extend for more than one hundred miles.

The generating station is also connected by a substantial transmission line over forty miles long with the system of the Southern Power Company in South Carolina.

Fig. 4.—Tallulah Falls Dam with completed and partially completed counterbalancing rollers for automatic flashboards.

Preliminaries

To facilitate construction a temporary power plant was built in the gorge utilizing one of the falls, and by means of turbine wheels, operating two 50 K. W. generators supplied electric light in the tunnel and elsewhere, also two 2,500 cubic feet air compressors furnished power for drills, derricks, etc. 1.5 miles of pipe 10″ diameter and under were laid to cover the constructions, and subsequently an 1,800 cubic foot steam compressor plant was added.

The main power station, located at the river side where there was little spare room, and the steep rocky slopes of the gorge made

necessary an incline which in 1,100 feet has a drop of 600 feet. This incline, with a rail gauge of 6 feet, and grades ranging from 43 to 100 per cent. was equipped with a 60 ton car, operated by a steam hoist, to which later electric power was also applied. The cement, brick, structural steel, and roof tiling required for the power house and switch-house, all of the hydraulic and electric equipments, were safely handled by this incline, and the car conveyed workmen between the top and bottom of the gorge.

The 52 ton generator rotors, sections of steel penstocks 5 feet diameter and 32 feet long, and the girders for a 60 ton crane were handled on the car, but the dimensions of the scroll cases of the

FIG. 5.—Automatic flashboards and counter-balancing roller in place under roadway over dam.

turbine wheels demanded their transportation on skids attached to the car.

This incline will continue as a means of reaching the power station or of delivering supplies or materials.

The Tallulah Falls Dam

The intake dam is a monolithic cyclopean concrete structure, 110 feet high, of the maximum cross-section shown on frontispiece, built on an arc of 900 feet radius. It closes a narrow gap in the gorge whose steep sides are indicated by the bottom width of less than 100 feet and abutments 444 feet apart, obtained in a vertical

height of 135 feet. The maximum width of base is 94′–4″, the altitude of the crest is 1,493 feet, the top of the flash-boards when in use, 1,500 feet, and the abutments and roadway 1,514 feet above sea level.

To facilitate construction three water-ways, each 10x12 feet, with a two-foot rise of arch, were formed in the masonry, one at elevation 1,389 feet and two at elevation 1,419 feet, which were later closed and the openings filled with concrete. Two permanent sluice-ways at elevation 1,425 feet are provided with 60-inch gates operated by winches located on balconies projecting from the roadway which surmounts the dam, their functions are to lower the water in the event that intake chambers or tunnel need to be examined or repaired, to supplement the overflow discharge and to remove accumulated silt.

This dam required 10,641 cubic yards of rock excavation and the placing of 39,163 cubic yards of cyclopean concrete, of which 34% by volume is represented by large "plums," stones obtained from the excavation and from a quarry close by. The unit prices paid were $1.50 per cubic yard of stripping, earth, or rock excavated for base and side slopes, and $4.80 per cubic yard of 1–3–5 concrete in place. The contractor was supplied with 1,000 cubic feet of air per minute at 100 lbs. pressure, and electric lights.

This dam forms a pool at elevation 1,500 feet (when flash-boards are up) which can be drawn 30 feet and supply 63 million cubic feet through the intake chambers into the pressure tunnel to temporarily augment the volume flowing in the river at the time.

During construction the flow of the river to be cared for varied from 200 to 15,000 second feet, the average approximating 450 feet.

A series of 9 piers, 4 feet thick, 13½ feet long and 20 feet high, carry a highway over the dam crest and form 10 bays, each 28 feet wide, in four of these bays flash-boards of the ordinary type, with tops at elevation 1,501 are placed. The remaining 6 bays are fitted with automatic counterbalanced flashboards, hinged at the crest of the dam in which a recess is formed to receive them when lowered. They are of Swiss design (Stauwerke) planned to hold water seven feet above the crest, that is at 1,500 feet altitude, but to automatically drop when this level is exceeded. They consist of frames of structural steel, sheathed with 3″ oak planks,

counter-balanced by reinforced concrete drums 26 feet long and 3′–3″ in diameter, each weighing about 17 tons. The ends of the drums are provided with geared wheels meshing into inclined racks, and with a plain section on which wire rope connected to the leaves is wound.

In operation, the flash-boards are in position to increase the depth of water 7 feet on the dam crest, when the counter-balancing drums rest at the bottom of the inclined rack, but as water over-tops the leaves they move downward on their hinges, and in so doing unwind the cables, giving a rotary movement to the

FIG. 6.—Front view of intake structure approaching completion.

drum, and causing it to rise as its geared pinions roll upon the sloping gear-racks. When the level of the water recedes so that the counter-balance becomes effective the drum descends by gravity, winding the cables and raising the flash-boards to position. To meet possible emergencies, provision is made to operate these flash-boards by hand winches placed on the roadway which surmounts the dam.

To reduce leakage at hinges and sides, strips of thin metal (readily renewed) appear to satisfactorily seal the flash-boards.

This is strictly a gravity section dam, except for lines of 60 lb. rails, placed at 4 feet centers near the two faces of the dam in the upper 20 feet of the structure.

The Hardaway Contracting Company of Columbus, Georgia, which constructed the dam at the unit prices mentioned, also did much other work in connection with the general installations, on a basis of cost plus ten per cent.

The prevailing daily wage rates approximated:

$4.00 to $5.00 for foreman,
$4.00 for derrick-men,
$3.50 for carpenters,
$1.75 for concrete men,
$1.50 for common labor.
Cement averaged $1.50 per barrel.

The Intake Structure

The Intake Structure was originally designed to be of mass concrete arches, but the disturbed rock strata exposed by excavation demanded structural reinforcement.

This intake consists of five chambers, each 10 feet wide and 44 feet deep, separated by division walls 3 feet thick and 38 feet long. Each chamber is provided with coarse trash racks outside of the control gates, which are 8 feet by 10 feet, and finer trash racks inside, with 1¼ inch openings between bars. Three of the latter have electrically operated cleaning appliances, driven by sprocket wheels and chains, to remove leaves and debris accumulating in a stream traversing a well wooded drainage basin.

The net screen area is 1,340 square feet, and the loss due to the screens is estimated at 0.1 foot for each generating unit in operation.

A heavy reinforced concrete girder, 5′x4′, spanning each chamber at midheight, is utilized to divide the length of two sets of inside screen bars and allow space for cleaning them.

The five chambers feed into one, common to all, which connects with the tunnel portal.

In constructing the intake, 3,237 cubic yards of rock excavation were necessary, and 2,672 cubic yards of concrete (1–3–5), 30,000 lbs. of reinforcing steel, 10 tons of structural steel and 5 tons of gate frames, were placed.

THE PRESSURE TUNNEL

Is of the horseshoe type with invert, and as lined has a maximum width of 12 feet, and a height 14.5 feet, giving a cross sectional area of 151 square feet. It has a slope of 0.002, and under maxi-

FIG. 7.—Pressure tunnel as lined, with collapsible forms and pipes for conveying concrete from pneumatic mixer.

mum conditions will pass 1,550 second feet of water at 10.3 feet mean velocity, but its normal capacity is calculated at 1,160 second feet flowing at 7.7 feet mean velocity.

FIG. 8.—Pneumatic concrete mixer used in lining pressure tunnel.

The estimated loss of head in the tunnel, based upon 5 generating units being in operation, when passing 1,555 second feet is 11.7 feet, and when delivering 1,150 second feet is 6.7 feet.

The bottom of the tunnel at the intake is 46.5 feet below the flash-board level, and 26.5 feet below the low water level which will prevail in the intake dam. When running full it will always be under 12 feet or more head at the entrance.

Its length is 6,663 feet, and the depth below the surface of the ground varies from 35 to 125 feet.

Except for short distances where soft material requiring timbering was locally encountered, the tunnel was driven through granitic rock, most of it so resistant as to limit the work done by air drills to a degree which entailed unexpected delay and expense, requiring experimentation with various drills to obtain a desired rate of excavation.

The tunnel was excavated from the intake and from the surge-tank or forebay ends, also from three intermediate adits driven from the gorge walls, and from one vertical shaft 10'x12' and 110 feet deep, thus permitting of attacking the work from ten headings. The total excavation was 52,653 cubic yards, an average of approximately eight cubic yards per lineal foot of tunnel, this excavation costing $5.48 per cubic yard.

The lining of the tunnel consisted of 1–3–5 concrete, placed by air pressure up to 100 lbs. per square inch behind Blaw collapsible steel forms in 40 feet sections. In the excavated section the minimum thickness of lining allowed was six inches, and a total of 18,966 cubic yards of concrete was placed, an average of 2.85 cubic yards placed per lineal foot of completed tunnel. The MacMichael pneumatic concrete mixer was of one-quarter yard capacity, and as much as 600 batches were placed in 10 hours, some of it conveyed over one thousand feet through 10 inch pipe.

A series of pipes, about 20 feet apart, inserted in the roof of the lining, were subsequently utilized to force grout into any voids or seams.

Through the courtesy of Mr. Adsit the following details of cost of lining the tunnel are available:

COST OF CONCRETE LINING. MAIN TUNNEL

Labor	$5.0417	per cu. yd.
Cement, costing $1.50 per bbl.	1.9658	" "
Miscellaneous materials	.4044	" "
Lumber	.1360	" "
Freight	.0650	" "
Transportation. Mainly of workmen	.15446	" "
Insurance	.1647	" "
Royalty on Mixers	.41155	" "
Miscellaneous cost	.10453	" "
Crushing stone	1.9886	" "
Quarrying stone	.85526	" "
Plasterers	.20157	" "
Cleaning tunnel	.3750	" "
Total	$11.86857	" "

Note: Steel concrete forms and depreciation on equipment are not included in above cost, the completed tunnel lining costing $12.07 per cubic yard.

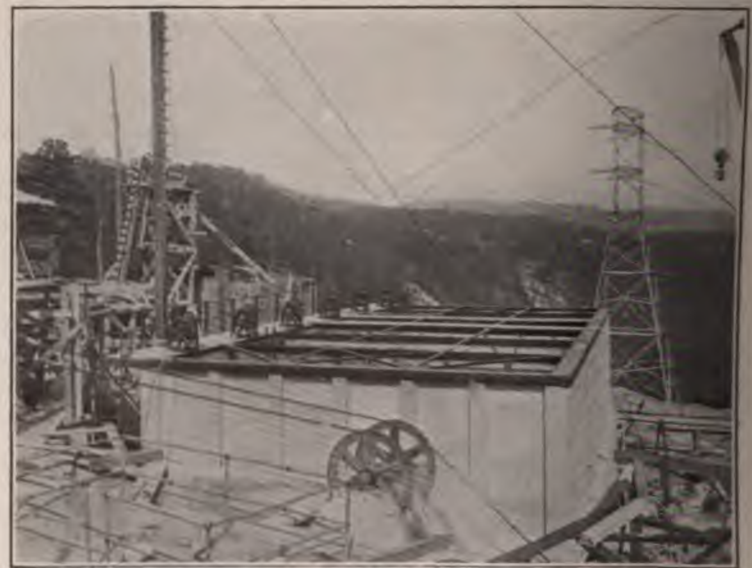


FIG. 9.—Top of forebay or surge tank with winches for controlling flap gates; a strain tower of the transmission line is in the background, and the sheaves, ropes, and top of car for the inclined plane are in the foreground.

Forebay

The tunnel connects the intake chamber with the forebay or surge tank, a structure 71x30 feet inside, and 93 feet high, of which 30 feet is above the ground surface, originally designed as a rock

Fig. 10.—Transporting rotor for electrical generator on the inclined railway to power station. The electric control gates and part of penstock in the background.

excavation with a concrete lining to surface level, topped by a 30 foot concrete extension, but the disturbed rock strata exposed

required a surge tank formed of a heavy structural steel frame placed in the rock excavation and imbedded in concrete to make the structure water-tight. Its construction required 5,761 cubic yards of rock excavation, 525 tons of structural steel held by

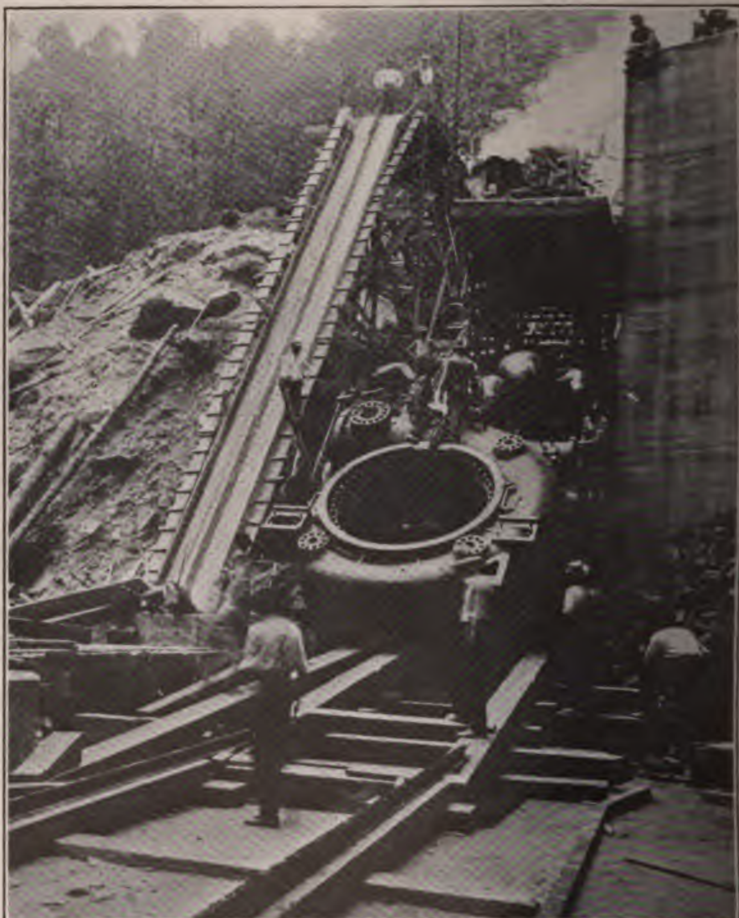


Fig. 11.—Scroll case for turbine water wheel delivered at foot of inclined plane.

55,000 ⅞″ rivets, 1,467 cubic yards of concrete and 400 cubic yards of reinforced concrete.

The erection of steel work in a deep rock excavation with little

room to spare, cost $13.33 per ton, and the concrete $7.50 per cubic yard to place.

The forebay is fitted with six emergency hinged flap-gates of

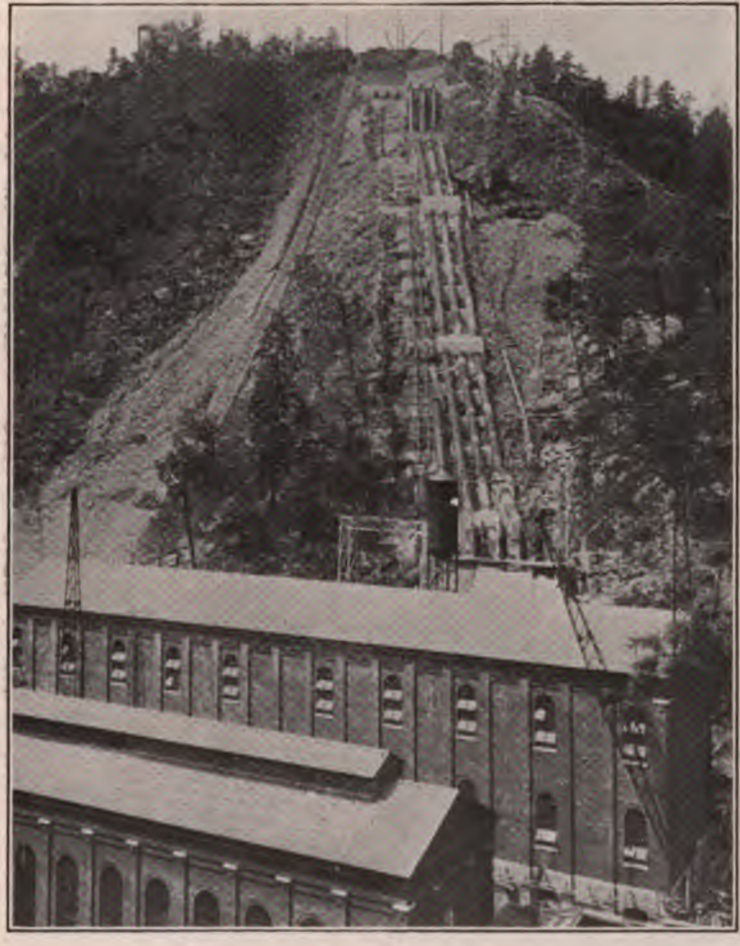


Fig. 12.—Penstocks during construction, power house and switch house in foreground, inclined railway to the left.

steel, each 7½ feet square, connected to winches, so that in case of accident to one of the penstocks its supply of water can be promptly stopped.

A maximum surge above the hydraulic gradient of 29 feet is

allowed to care for a sudden interruption when the full power of the plant is in service at 25 per cent. overload.

Penstocks

From the surge tank six horizontal steel penstock extensions, 100 feet long and five feet in diameter, are carried through rock tunnels in which they are grouted, each having a 60-inch motor operated gate valve controlled from the power station in the gorge 500 feet below. An 8-inch air relief is also placed on each extension.

From the gate valves the penstocks are laid down the steep side of the gorge on concrete cradles and secured to massive anchor blocks, where the direction changes. Below each of these bends an expansion joint is inserted. Five penstocks are in place and provision made for a sixth. They are each five feet internal diameter, slightly more than the upper half of the penstock (about 700 feet) being of riveted steel $\frac{3}{8}$ inch to $\frac{5}{8}$ inch thick, the lower portion of imported hand welded steel $\frac{5}{8}$ inch to $\frac{13}{16}$ inch thick. This latter was made in Germany and shipped in sections up to 32 feet in length with male and female swelled joints at the ends drilled for rivets.

The steep declivity of the gorge side made placing and aligning of anchor-blocks or cradles and assembling of penstock sections difficult. As most of the latter were connected in hot weather, it was impossible to do the riveting except at night. 47,000 cubic yards, mostly rock, were excavated. Tests for leaks demonstrated that Messrs. Wm. B. Pollock & Company, to whom the penstock contract had been let with an allowance of six mills per pound for erection, had made a most satisfactory job under adverse conditions.

The approximate cost of the penstocks in place and connected, was for the 605 tons of hand-welded steel pipe \$132 per ton, and for 565 tons of rivetted steel pipe \$80 per ton.

The penstocks pass under the switch house to Venturi meters with 35-inch throats and terminate in the power house at hydraulicly operated gate valves 45 inches diameter which control the water turbines.

The calculated loss in head in a penstock, when passing water for the normal load on a generator of 10,000 K. W. is 15 feet, due to a velocity of 11.7 feet per second; with a 25 per cent. overload

the friction loss is estimated at 22.5 feet. The Venturi meters reduce the head by two feet under normal load and 3.4 feet with the overload.

FIG. 13.—Penstock during construction, showing the welded section with swelled riveted joints, expansion joints, anchor blocks, and cradles.

GENERATOR HOUSE

The Generator House, 192 feet long, 48 feet wide and 49 feet high, from the generator floor to the lower chord of the roof trusses, is arranged to accommodate six hydro-electric units, each operated by a turbine wheel in the sub-floor or basement.

It is of structural steel framework, with curtain walls of red brick laid in red mortar and trimmings of white marble window sills and pilaster-caps, resting upon foundation walls of cyclopean concrete, which are carried 1½ feet above the main floor. It is provided with a 60-ton electrically operated crane. The roof has a monitor containing about 1,200 square feet of window area and is covered with large reinforced concrete tile, colored red and resting upon purlins of 15½ feet span, spaced 4 feet centers. The doors of the principal entrances are of rolling lift steel type, and

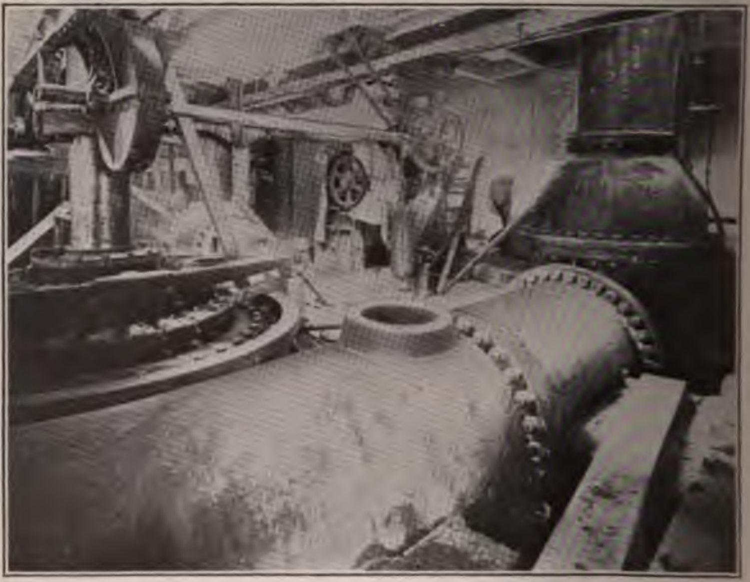


Fig. 14.—Inlet end of the turbine scroll case with 45-inch hydraulic control valves, also showing the operating apparatus of the wicket gates, the main vertical shaft connecting turbine and generator and the oil pressure pump geared to the main shaft.

the windows are of "Fenestra" steel-sash type, glazed with double thick American sheet glass. The monitor sashes and about half of the other sashes are manipulated by the "Drouve" system of window operation.

The Basement (turbine floor) is divided into 28 feet chambers by heavy concrete walls or piers, 5 feet thick, which are pierced by three openings. The piers are connected by two 5-feet steel plate

girders, which are cross-connected a few feet on each side of the center line by two short 5-feet steel plate girders. The girders support and carry to the piers the weights of the generator frames and moving parts, and the floor about and between them is filled with concrete 5 feet thick for stiffness, an opening being left to permit the passage of the runner, shaft, etc.

A thinner floor is used between the girder and the walls of the station, whose foundations are thus relieved of the machinery

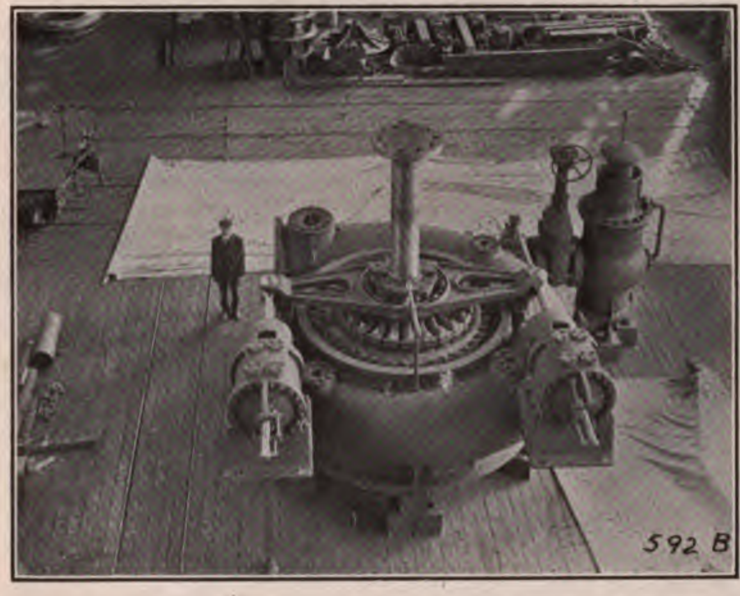


FIG. 15.—The complete turbine assembled in the shop ready for shipment. Water enters at the flange near the standing figure, passes around through the scroll-case, and is admitted to the runners by wicket gates, the operating mechanism of which appears on the top of the case. This mechanism is moved by a walking beam to which power is applied by two oil cylinders in the foreground. To the right the relief valve is indicated.

load. The turbine floor contains the turbine units with mechanically and electrically driven oil pumps, oil reservoirs, gate operating mechanism, control and relief valves, etc.

The main floor contains the generators with superimposed exciters supported by an oil-thrust bearing between them carried

upon the generator frames, and the governors, a D. C. switchboard, rheostats, etc.

An elaborate switchboard placed on a gallery gives control of the electric connections between the various units and the transformers, switches, etc., in the high tension house.

To supply direct current to operate auxiliaries and an air compressor for cleaning purposes, a 50 K. W. generator is driven by a Pelton impulse wheel connected to one of the penstocks.

Generating Units

The turbines are of modified Francis type constructed by the S. Morgan Smith Company, and operate under higher head than most other reaction wheels in the country.

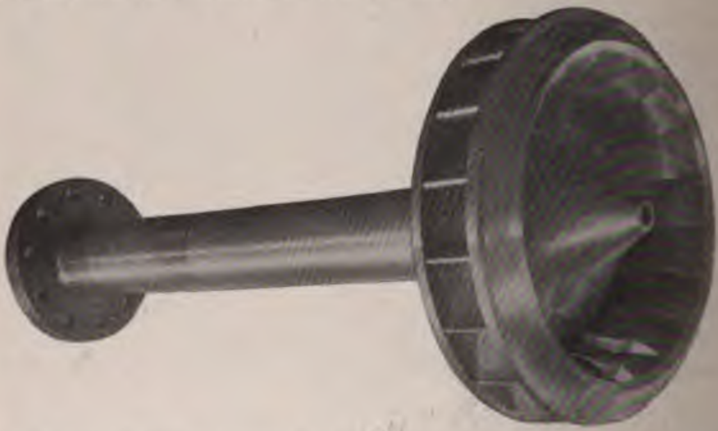


Fig. 16.—View of bronze runner showing arrangement and shape of buckets, the interior cone, and the stub shaft which connects with the generator shaft.

Each of the five units in place consist of a turbine scroll case and runner, placed below a 10,000 K. V. A. General Electric generator, which in turn is surmounted by a 100 K. W. exciter; the runner of the turbine, the rotor of the generator and the exciter being rigidly secured on a vertical shaft, making 514 revolutions per minute.

Water from the penstocks passing the 45-inch control valves enters the scroll cases, which are iron castings in one piece 14 feet diameter, weighing when finished 27 tons each, and is directed through 24 forged steel wicket gates to the bronze runners. After

imparting energy to the runners water passes through curved steel draught tubes embedded in concrete foundation to the tail race. The center of scroll case is 22 feet above normal tail water.

A 22-inch relief valve is connected to each scroll case.

The cast bronze runners, 55¾ inches in diameter, weigh 3,200 lbs. each and have 18 buckets 7 5/16 inches high. As the turbines have developed over 18,000 horse power, each of these buckets may be considered as communicating 1,000 horsepower to the main shaft of the unit. Incipient pitting on the backs of buckets resulted in experiments as to the most desirable composition of bronze to employ, 88 copper, 10 tin, and 2 zinc, being the original formula.

The wheels are installed under a guaranteed efficiency of 83 per cent., with a bonus for exceeding or a penalty for falling below the guarantee.

Operating normally under full head, each turbine requires 230 cubic feet of water per second, or 304 second feet when working at 25 per cent. overload.

Provision for testing the efficiency of the wheels is made by recording Venturi Meters, by Pitot tubes which can be inserted in the throats of these meters, and by a submerged weir in the tail race, and it is expected that when made these tests will supply valuable data as to friction losses in various portions of the hydraulic construction and may modify some of the factors mentioned.

In round numbers each generating unit with its electrical connections, required an outlay approximating $110,000.

A Comparison

In clearing the area to be covered by the storage reservoir under construction a primitive grist mill was removed, a view of its wheel being introduced to indicate a comparison.

This 38-inch wheel, carved out of two sections of solid oak 6 inches thick, held together by an iron band, rested on a stone "step" from which it was raised by levers when the mill stone was to be stopped. It received water from a chute and vented it without draught-tube. Operating under 20 feet head it developed a few horse-power, but the carefully studied bronze runner installed at Tallulah Falls under 600 feet head, although less than twice the diameter of the wooden wheel, produced 18,600 horse-power.

As Mr. E. U. Gibbs, of the S. Morgan Smith Company, is present I have requested him to describe in detail the construction of the

FIG. 17.—Old wooden water wheel common to the Appalachian Mountain District.

water wheels, the operation of the wicket gates by oil cylinders, the duplex oil pressure system, the Weber governor and the support of the turbine runner main shaft and rotor of the generator, weighing 66-ton with 14 poles, from an oil thrust bearing between the generator and exciter.

On a recent visit I noted the fly-wheel effect of 75 tons (the combined weight carried by the oil thrust bearing) when a unit revolving at its normal speed, 514 revolutions per minute, was shut down. In 16 minutes the revolutions were 200, and from 40 to 45 minutes are consumed by the rotating parts coming to rest.

FIG. 18.—Three of the 10,000 K. W. generators during construction. In two the exciters are in place, and in the third the thrust bearing is in position.

A nickel steel shaft, 14 inches in diameter, rigidly connects each turbine runner and generator rotor with its 14 poles, which produces alternating electrical current at 60 cycles, 3-phase and 6,600 volts, and the fans for cooling each generator pass 35,000 cubic feet of air per minute, a quantity sufficient for a blast furnace producing 350 tons of pig iron per day.

But this paper is to be confined to the hydraulic features, leaving for others detailed description of the generator and exciter construction, the elaborate system of switch control, the switch

house 250 by 50 feet, of similar design to the generating station, with transformers on lower floor and high-tension switches above, the lightning arrester system, the towers, insulation and wiring of the main transmission lines and the extensive open-air sub-

FIG. 19.—Rotor for 10,000 K. W. generator on shaft ready to be set. This rotor with its pole pieces weighs 66 tons.

stations at Atlanta and other distributing points to which the 110,000 volt current is conveyed. The generators and the electrical equipment of the plant were supplied by the General Electric Company.

The plant described is not unique in the head of water applied, the capacity of generators, in use of pressure tunnel, in the high gravity section concrete dam, in length of transmission line, nor in the high voltage, nor in the storage which is to be provided for

FIG. 20.—High tension switches in the upper floor of the Main Switch House.

stream regulation. Elsewhere higher heads are employed, larger generators are in service, higher dams and longer tunnels are in existence, more liberal storage is provided, and the current gen-

erated is transmitted to greater distances at as high or higher voltages than at the Tallulah plant.

But for the eastern portion of the United States the head used is abnormal, and this head applied to reaction wheel has not been exceeded, while the conditions which influenced the combinations described are sufficiently unusual to encourage the presentation of data before the Engineers' Club.

The hydraulics of the plant should be supplemented by details of the reinforced concrete dams of the "hollow" type, which are to form the storage reservoir; but unfortunately at the present time litigation in progress makes unwise more than a reference to the features from one officially connected with their construction.

DISCUSSION

(Mr. E. U. Gibbs exhibited a number of slides made from shop drawings, and explained the details of construction, these explanations being necessarily abstracted in the text.)

Mr. Gibbs.—In accepting this invitation I shall confine myself to explanation of the slides.

The original design contemplated wheels operating under 600 feet head at 514 R. P. M., capable of producing 16,000 H. P. A test of a runner in the Holyoke flume under 16 to 17 foot head demonstrated that when operating at 600 feet head the wheels should produce 17,500 H. P., and as the generators were liberally designed, the Georgia Railway & Power Company accepted the latter rating.

Water enters the scroll case through the control valve, passes around it, through gates and runners, to the central discharge draught tubes.

The main shafts of water wheel and generator are rigidly connected, the entire rotating element being carried on an oil thrust bearing.

The turbine gates are controlled by a regulator or actuator (governor) placed on the floor alongside of the generator and operated by a belt from the turbine shaft and connected by spiral gears to the governor head or centrifugal balls which move the valves and control the oil supply to the operating cylinders below.

These cylinders are connected through piston rods to a walking beam, a gate ring, and the gate arms which regulate the volume of water flowing into the runner.

The gates and gate stems, of forged steel, are formed in one piece. The scroll case is of cast iron tested to a pressure of 400 lbs. to the square inch; it is made in one casting weighing about 54,000 lbs.; the size of the inlet being 44" in diameter.

Should the gate suddenly close while the wheel was operating there would be a serious water hammer at some point in the pipe if there was no relief; but as the piston moves to close the gates a connection overhead raises the relief valve which automatically closes slowly, bringing the water to rest in the pipe in from 10 seconds to a minute and a half, thereby eliminating the water hammer.

The piston rods of the operating cylinders are directly connected to the walking beam or cross bar, no cross head being used. These rods run directly through the

cylinders, and the pistons are rigidly fastened to them inside. The versed sine of the angular movement was so small that the operating clearance was sufficient to eliminate any binding or leakage in the stuffing box in the cylinder.

The bearing for guiding the turbine shaft (which is 13″ in diameter, of nickel steel) is made similar to a stern bearing on a steamship; made of strips 2″ wide distributed around the shaft and lubricated by water passing in through the bearing and out through the bottom into the chamber over the top of the runner inside of the casing.

A cast steel guide ring weighing 11,000 pounds is placed inside of the flange of the scroll case to tie the case back and take longitudinal stresses. The water passes through openings with hollow veins connected with the chamber above the runner.

The main shaft is of nickel steel weighing 8,000 pounds, but the wheel and generator shafts when connected, weigh 20,000 pounds. The size of the scroll case was such that special cars had to be built to transport them, and when loaded the bottom of the scroll case was 4 inches above the railroad track. The thrust bearing on top of the generator which supports the generator, turbine runner and shaft, is supplied with oil by two pumps, one driven by an electric motor, and the other by a Morse chain drive. When the pressure reaches 140 pounds per square inch on the thrust bearing, the switch throws the motor into operation and starts the pump. As the load increases the discs are separated, but when it diminishes, the pressure will rise automatically to balance the load.

The hydraulically operated gate valve which controls the admission of water to the scroll case is of cast iron 48 inches in diameter and weighs 38,000 pounds. The relief valve weighs 14,000 pounds. The complete turbine unit weighs 375,-000 pounds.

Mr. Gibbs exhibited a log of the Holyoke test, showing the different gate openings under which the turbines were run, the heads produced, the revolutions, the horse power, and the efficiency.

These indicated an efficiency of 87 per cent., and that 18,300 H. P. would be produced at full load.

Dr. Carl Hering.—What is the difference between minimum waterflow and the power of the station? In a 24-hour flow? I understand that these Southern water powers are very variable in their flow of water.

Mr. John Birkinbine.—The minimum waterflow—that is, the extreme minimum from 191 square miles would probably approximate 100 cu. ft., which would give something like 3,700 K. W. continuously. The minimum is expected to be offset by the storage of 1,340 million cu. ft. in the reservoir, so that we do not expect to have to fall back upon the minimum at any time. The average flow of the river is about 650 second feet. You can see that it would keep up very well. The streams are variable, naturally.

Mr. Chester Wilson.—I was wondering at the penstocks taking first a horizontal and then an inclined position. Is there not a great loss of power by reason of the changes to a nearly horizontal position?

Mr. Birkinbine.—I will not say there is a great loss of power.

Mr. Schreiber.—I would like to ask whether the calculated losses for the generators have been checked at all, and whether there is any deficiency in the actual efficiency of the plant as installed? Are there any variables?

Mr. Birkinbine.—In plants of such magnitude, particularly where they are forced to go into operation before they are ready, there is no opportunity for test, and none of the units have been tested yet, because they have been getting into working condition. On two of the units the electrical manufacturers have to make some change, and until everything is in final shape, tests will not be made. It will be a matter of some months until the final checking up.

Mr. J. C. Trautwine, Jr.—Did Mr. Wilson's question refer to the possible resistances of the bends in the penstocks?

Mr. Wilson.—Yes. It would seem to me that when the water struck the lower side, it would add very much to the friction and so slow the flow of water. it would seem only a matter of excavating rock to avoid making the bends.

Mr. Trautwine, Jr.—I think the loss of head due to a bend is generally very slight.

Mr. Wilson.—Referring to the commercial side of it, the Tennessee River Company have recently proposed selling the power to large consumers at a very low price per K. W. H., and they got down to some figure approximating that quoted by Mr. Birkinbine; but I was told you could not rely upon that as a plain statement, because there is hooked on to it some sort of a new technical expression which gives the opportunity of applying the screws to you in getting a price. It escapes my memory now just what it meant, but when they say "one-half cent" per K. W. H. they do not mean a straight supply of current in that way, but dependent upon some sort of conditions in reference to the supply of power. We have power within the same distance here, on the Susquehanna river, which, of course, is very low, but still I understand the Susquehanna river power is very efficient considering the fall is so small, and inasmuch as some of the Southern cities are using this power for general purposes, I was wondering whether the fusion of associations controlling water powers might not render such general use less economical, as compared with the coal pile. We could hope that such conditions would be broken. If they could get down to small prices, we might be permitted domestic heating by electricity.

Mr. Birkinbine.—Low prices are made to large consumers for busbar delivery at the generating station, or at the distributing station. Under general conditions, I do not look for such terrible disaster from combinations as Mr. Wilson thinks, because I realize that the hydro-electric plants are up against a hard proposition when they must compete with steam turbines direct connected to generators run at a high velocity, and there need to be very satisfactory market conditions for generating companies to make money with power costing them more than 6 or 7 mills per K. W. H. at the busbar. I think this applies to both steam and hydraulic power plants of large capacity.

Dr. H. M. Chance.—Has there been any attempt to measure the amount of sediment carried by that stream, and is there any chance of filling it up?

Mr. Birkinbine.—Dr. Chance is ahead of the game. We have not had a real good freshet there yet. As far as the intake dam is concerned, it will make very little difference. This is only drawn down 20 feet in operation, but it can be lowered 75 feet by the sluiceways if necessity arises. The storage reservoir is a pool 9½ miles in length and holds 1,340 million cubic feet so there is room for some sediment in addition to water.

PAPER NO. 1139

REPORTING ON PUBLIC SERVICE PROPERTIES

By E. P. ROBERTS

Read April 14, 1914

INTRODUCTORY

The engineer has many opportunities to benefit mankind; by research work, assisting younger engineers, and endeavoring to assist in advancement of all kinds, civic, industrial, sociological; along many of which lines his training makes him especially useful. The paper this evening deals only with his employment by capital to obtain returns for capital, and, therefore, values are financial values. *The engineer is paid in cash to deliver in cash.*

EMPLOYMENT OF ENGINEER ON FINANCIAL BASIS

Engineers often complain that their compensation is not proportionate to their ability and responsibility. After-dinner speakers especially dwell on such point. But engineers are not unique in this respect. From ministers, lawyers, doctors, architects, bankers, manufacturers' associations, trade associations, and other groups, the same complaint is heard—"If it were not for us, where would be our civilization? We are the great benefactors of the human race, pay us what we consider is in accordance with the benefit we confer."

In a general and broad way, every one receives for his services in proportion to supply and demand. To such extent as the measure of compensation is financial, each person receives an amount of money based on what the buyer believes he must spend to obtain that which he desires.

When Capital employs an engineer, it is on the basis of financial benefit to Capital, and the engineer accepts employment on such basis.

Duty of Engineer

If the engineer does not furnish to Capital the best advice obtainable, he is as dishonest as if he does not make every effort to obtain full value from a contractor whose work he supervises. It is the engineer's duty to study each and every question, which either directly or indirectly affects such portion of the problem as is in the engineer's charge, and then to advise the representative of Capital to the best of his ability. If personally he is not able to advise competently, he should obtain such advice and pay for it, or inform his superior officer, or client, hat certain questions, or certain phases of some one question, should receive greater attention and investigation than his knowledge or available time will permit.

Training Other than Engineering

Many engineers have had no training in financial matters, but it is becoming more and more realized that the engineer should have a broad training, including a knowledge of the principles of economics, accountancy and business law, and should be able to study engineering problems with relation to financial results. There has, possibly, been a feeling that information along financial lines was so difficult to obtain, or so intricate, or unscientific in character, that the engineer could not expect, by the expenditure of such effort as practicable, to obtain any knowledge which would be helpful. The engineer appreciates the fact that he must obtain a broad and general engineering knowledge before specializing, and then must specialize before he can make exceptional progress in any line, and concludes that there is no time available in which to obtain knowledge along other lines, or there is no necessity for it, or both. Whatever the reason for such conclusion, it is erroneous and harmful to him and to the profession.

If representatives of the legal and engineering professions in any one city are compared, it will be found that more lawyers than engineers are consulted on financial questions. Lawyers receive a broad general training as do engineers, and then usually specialize. There are always a number of prominent lawyers who are directors in banks, and others are appointed receivers for bankrupt properties. Of course, such receivers are frequently appointed by their professional brethren; in other words, by judges; Frequently, if not usually, executive ability is more important

than legal ability; in fact, frequently, legal questions do not represent 10% of the problem. Without reference, however, to appointment by the Court (acquaintanceship or professional courtesy), probably the average business man would select a lawyer rather than an engineer for such position, even when the business is a manufacturing or transportation one.

Engineers as Railroad Executives

That frequently engineers are good executives is evidenced by the growing tendency on the part of steam railroads to appoint executives from the engineering force. This is especially interesting in view of the increasing difficulties confronting railroad executives at the present time; as the result of regulation by the Interstate Commerce and Public Service Commissions. In other words, now that the business must be conducted on a basis, Wall Street methods, or those frequently considered as such, are no longer permissible.

Comprehensive Advice

I have already stated that the engineer should have one aim, namely, to obtain dividends for capital, but if he is only able to advise as to the technical design and construction cost, it is evident that his usefulness and, therefore, the value of his advice is exceedingly limited. He may be able properly to advise correctly as to the financial results as between two different classes of structure. An example of such simple character arises when considering the comparative advisability of building a trestle structure or a comparatively permanent bridge. He may be able to report as to the first cost and proper allowance for maintenance and depreciation of each, and possibly correctly state that, for the case under consideration, the cheaper structure is the preferable one if considered on the direct basis of cost per year, including interest, maintenance and depreciation; or that from the standpoint of fire or floods, it may not be advisable. He may properly consider the funds available and financial demands at other points and state that the erection of a permanent and expensive structure can wisely be left to the future. The above example is a comparatively simple one, though frequently such simple cases are not sufficiently investigated by the engineer.

Ability to Appreciate Aim and Methods of Co-operating Experts

The engineer cannot expect to become an expert lawyer, accountant, economist, or financier—at least, most of us would not be so optimistic. He should, however, *appreciate and understand* the result of the investigation made by experts along such lines and the application of such results to the work of the engineer.

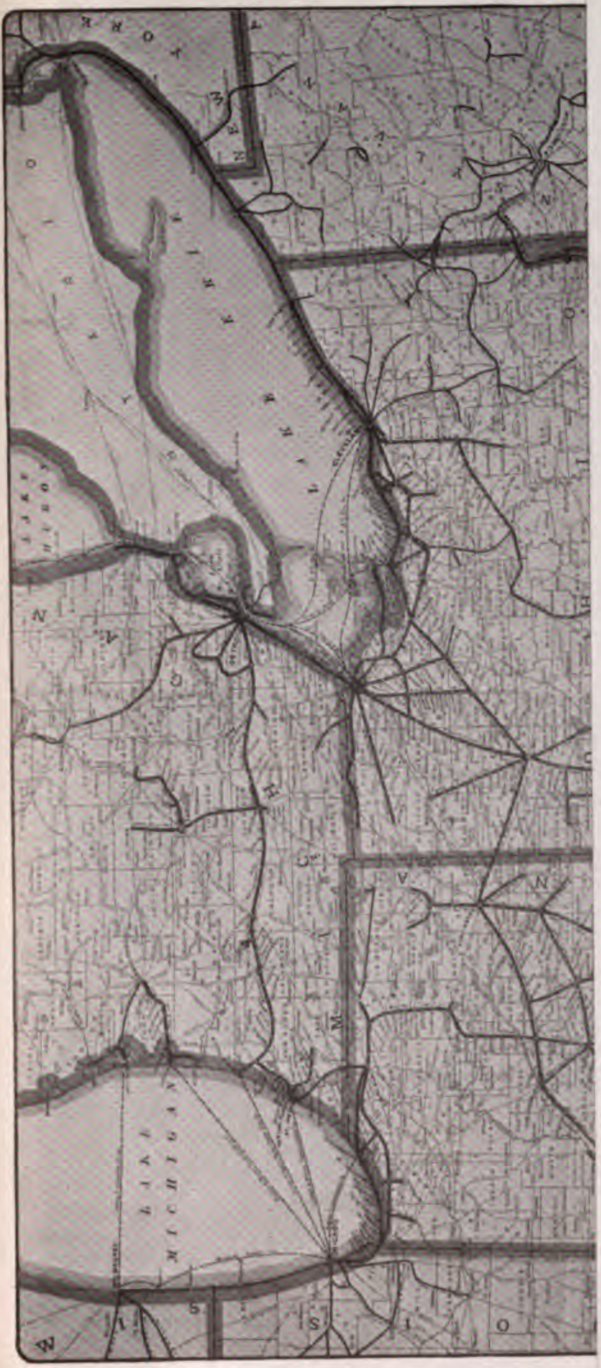
Co-operation

The engineer should also appreciate the fact that it is part of his duty of the engineer to inform other experts as to many facts which often they would not know existed unless he calls same to their attention, and, in addition there are many factors the full value and effect of which cannot be ascertained except by co-operative effort.

Even in purely technical work the engineer must rely upon others. If he is in charge he should understand the general principles of the methods followed by his assistants in order to appreciate the value of the result obtained by them and to take full advantage of their abilities. For example, many of us are no longer able to work out problems in higher mathematics, but if we did not know what could be best accomplished by the application of same, or understand the meaning and comparative value of the answer submitted, we would not instruct some one to make the investigation or calculation; in fact, we might not have such a man in our employ because we would not feel the need or appreciate his usefulness. To obtain the answer to a technical example is important, that is what we pay the assistant to do. To ascertain the value of the answer and place it in the proper place with relation to all the other factors of the main problem, is what our employer pays us to do.

Technical School Training

In the past few years more and more attention has been given in technical schools to instructing the students in the fundamental principles of accounting, business procedure, and business law. A leader in such work is your former fellow townsman, Dr. A. C. Humphrey, now President of the Stevens Institute of Technology. He, by virtue of his business in addition to technical training, realized the importance of starting the students along the lines



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above mentioned in order that they might, to as great a degree as practicable, not only understand the general principles, but, of more importance, appreciate their bearings upon and relation to the technical work of the engineer. Lectures and examinations on such subjects have been for many years, part of the regular work at Stevens. Recently a conference was held at Stevens upon "The Engineer's Part in the Regulation of Public Utilities." The conference was attended not only by alumni and guests, but also by the under-graduates. It was addressed by a number of prominent corporation officials and by a member of a public service commission. All were Stevens alumni.*

It seems to me that many of those present, though especially the students, will become bigger men and more competent and fully rounded out engineers because of the conference; not so much on account of the information conveyed, valuable as it was, but because of the inspiration resulting from hearing such subjects discussed under conditions especially tending to influence young men.

Reports on Public Service Properties

1st. What is a Public Service or Public Utility Property?
2d. Why is it constructed?

Answer to Question No. 1

Evidently the answer to the first question is that a public service property is one constructed to give service to the public. The service may be rendered by the community—municipal ownership—but such is not the ownership of the properties now to be considered, though the same general principles should be applied, including engineering, operation, and accountancy.

A public service property is usually considered as one furnishing service to the public, but the ownership of which is private. The peculiar characteristic features are that the owners agree to

* "Those who read papers were President Alexander C. Humphreys, '81 Newcomb Carlton, '90, Vice President of the Western Union Telegraph Co. John W. Lieb, Jr., '80, Vice President of the New York Edison Co., and James E. Sague, '83, member of the Public Service Commission of New York State. George J. Roberts, '84, Vice President of the Public Service Corporation of New Jersey, and George Gibbs, '82, consulting engineer of the Pennsylvania Railroad, were on the program, but were unavoidably prevented from attending. A letter from Mr. Gibbs, stating his views, was read by Dr. Humphreys."

give adequate service, and the public agrees to give the owners the opportunity to furnish the service. Certain requisite privileges are granted, such as condemnation for right of way, rights in the streets, etc. Frequently, not always, the public permits, or practically assures, a monopoly, either during "good behavior" or for a specified period.

The person who serves is a servant, at least according to the dictionary, but in fact, the duties of the servant are liable to be forgotten. The person served is the employer, or "boss." Sometimes the latter term not only seems more personal, but also more applicable.

Commissioner C. J. Prouty, of the Interstate Commerce Commission, in an address to the Cleveland Chamber of Commerce, Jan. 20th, last, on "The Duty of the Public to the Railway" stated: "Now, to go back to my proposition that the railroad is the servant of the public. Assume that you had an intelligent servant, who was especially skilled to do a particular thing, how would you as a prudent master treat that servant? You would certainly give him enough to live on, because he couldn't work until he could properly subsist."

Mr. Prouty also stated, referring to the railroads, that the servant was at one time the master, and, if I correctly understand his statement, that there is now a tendency to starve the servant and to take away both incentive and ability to give adequate service.

Another way of considering the relationship is that of a special partnership agreement between the Public and the Public Service Corporation.

Franchise Period

Franchises may be short term, perpetual, or indeterminate. Short term franchises have many defects, perpetual franchises frequently, possibly inherently, do not properly protect the public, or the owner, or both, they are either "wide open" or have unwise restrictions. Indeterminate franchises, sometimes termed indeterminate permits, are permits to control and operate during "good behavior" on the part of the corporation legally supposed to be *enjoying* the operation, whatever may be the facts as to such enjoyment.

It is also often presumed that the owner will be protected from competition because it is in the interest of the public that the utility be a "monopoly," and that if the owner exercises reasonable care in designing, constructing, and operating the utility, that he will be permitted to obtain and retain such form of enjoyment as results from dividends.

To an increasing degree it is becoming a fact, that Public Service Commissions are not only protecting the public, but also are, or at least some are, protecting the owners and instructing the public as to not only what is fair treatment, and also what is in the permanent interest of the public.

Franchise Basis

In the issue of January, 1911, of the American Academy of Political and Social Science (Electric Railway issue), the statement is made that the Wisconsin theory is that the franchise is a privilege conferred by the State and not a contract between the municipality and the company, and that it is subject to State regulation when and as regulation is required.

Massachusetts permits a certain "location," and other States have different angles of approach, but, I believe, that the general tendency is toward control and protection. Control, as to financial scheme and securities issued and as to service; protection, as to avoidance of all forms of special tax, for which the public, or rather the users, must pay or not obtain adequate service, and protection from competition.

An indeterminate franchise is somewhat similar to an indeterminate sentence, as it is also dependent upon "good behavior." Both indeterminate franchises and indeterminate sentences have good features, though the particular recipient may not always appreciate the application.

Answer to Question No. 2

The second question is "Why is a Public Service Property Constructed?"

The answer might seem to be because of the public need. The correct answer is because some one thought it would pay *him*. It is the same reason which exists for putting forth any effort. The question always asked is, "Will it be profitable?" In a business transaction the profit is measured in money. There must be

a promoter, and this promoter is a most helpful member *of* the community, though not always *for* it.

Why is an engineer employed to report on a public service property?

Usually in order to inform his client as to whether the property has paid, or will pay, or both, on the investment.

The engineer must, or should be, a skilled prophet—which thought, coupled with the previous statement that the engineer is paid in cash to deliver in cash, gives rise to the following title as possibly a more fitting one for the subject of my paper than the one chosen; it is "The Engineer as a Prophet, or the Profitable Engineer."

Example of Investigation on Which to Base Report

I propose to now consider the preparation of a report upon a proposed interurban electric railroad. I will, later, touch briefly upon some special features of reports relative to existing properties and properties other than interurban railroads.

What is the procedure prior to the construction of an electric interurban railroad?

Promoter

First, there is, and must be, a promoter. Some person, or persons, conceive the idea that if an electric road is constructed to serve a certain territory that there will be a profit in it for him, or them. The promoter, like every one else, wants "all the traffic will bear." There was a time when he took all the profit and part of the capital, but it was done "under cover" and later it came to be realized that this was similar to taking off more cream than was in the interest of, or fair to, the public. For a short period, some persons even considered that the promoter should not have any profit; this was absurd. It is now becoming somewhat appreciated that the promoter is entitled to a profit. The man who initiates, takes the risk, and succeeds, should receive a liberal reward and it is both absurd and against self interest to prevent it.

Engineer Starts

We will presume, as premises:

1st. That the promoter has had experience, and, therefore, before proceeding far, or making any entangling agreements, employs an engineer to prepare a report.

2d. That the object of the report is to ascertain the required investment, probable percentage of profit from operation and security of the investment. Division of profit and loss as between ground floor, attic, and basement, or temporary occupancy of other floors, is not a problem for the engineer.

Land deals and all other "inside" features are not to be considered, or, if they are, should be reported as such. They may be legitimate, or not, but usually they are not, and should not be considered by the engineer.

Margin for Stock Very Small

The engineer knows that *at the best,* there will be only a slight margin of profit for the stockholder. It is his duty to consider all the features which affect cost and income (gross and net) insofar as they can be predetermined, and to ascertain what investment is necessary in order to obtain the greatest *rate* of return. Practically all such properties are constructed, to a considerable degree, by capital obtained from the sale of bonds, and the equity of the stockholder is small whatever the figures on the stock certificates. Stock has the speculative interest. Bond holders are supposed to be secure. At this time, we will consider capital without reference to the character of subscription, or form of security, or evidence (bond or stock) of definite amount or share interest in the property.

Rate of Return

It is *rate* that is vitally important.

For a given net income, the less the investment, the greater the rate.

Increased investment may increase or decrease gross income.

Increased investment may increase or decrease net income.

Amount of investment and net income are affected by:

1. Location.
2. Design.
3. Construction.
4. Operation.

To a large degree the engineer decides as to Nos. 1, 2, and 3. The result of his work largely affects No. 4.

Procedure

The general procedure which I prefer is as follows:

General Survey

1st. Obtain a bird's eye view of the territory. To obtain this, make a preliminary study of available maps, including topographical, note general location of proposed road, the location of the territory which apparently might be served, and such factors as might seem, until definite information is obtained, to restrict or enlarge the territory served, to a greater degree than would be the case if it were based on a strip two or three miles each side of the road. An arbitrary assumption of uniform width of territory served is misleading. Location of rivers paralleling the route, high ridges or hills near the route, other railroads, either paralleling or at an angle to the proposed road, and other physical and transportation features, all affect the ease of access to the road, the traffic which should be secured and the service which should be offered.

Industrial Developments

Having in mind a possible general location, then some preliminary knowledge of the characteristics of the territory is helpful before going over the route.

What is the general character of the industries? Why did they develop? Upward or downward tendencies? What probable future? Can the proposed road help the development?

Mining—fluctuating in value to an electric road.

Manufacturing—less fluctuating in value to an electric road, but unless diversified, quite variable.

Agricultural—usually less tendency to fluctuations, but depends somewhat upon nationality of farmers; generally farming communities spend less money for unnecessary riding than does a mining or manufacturing community.

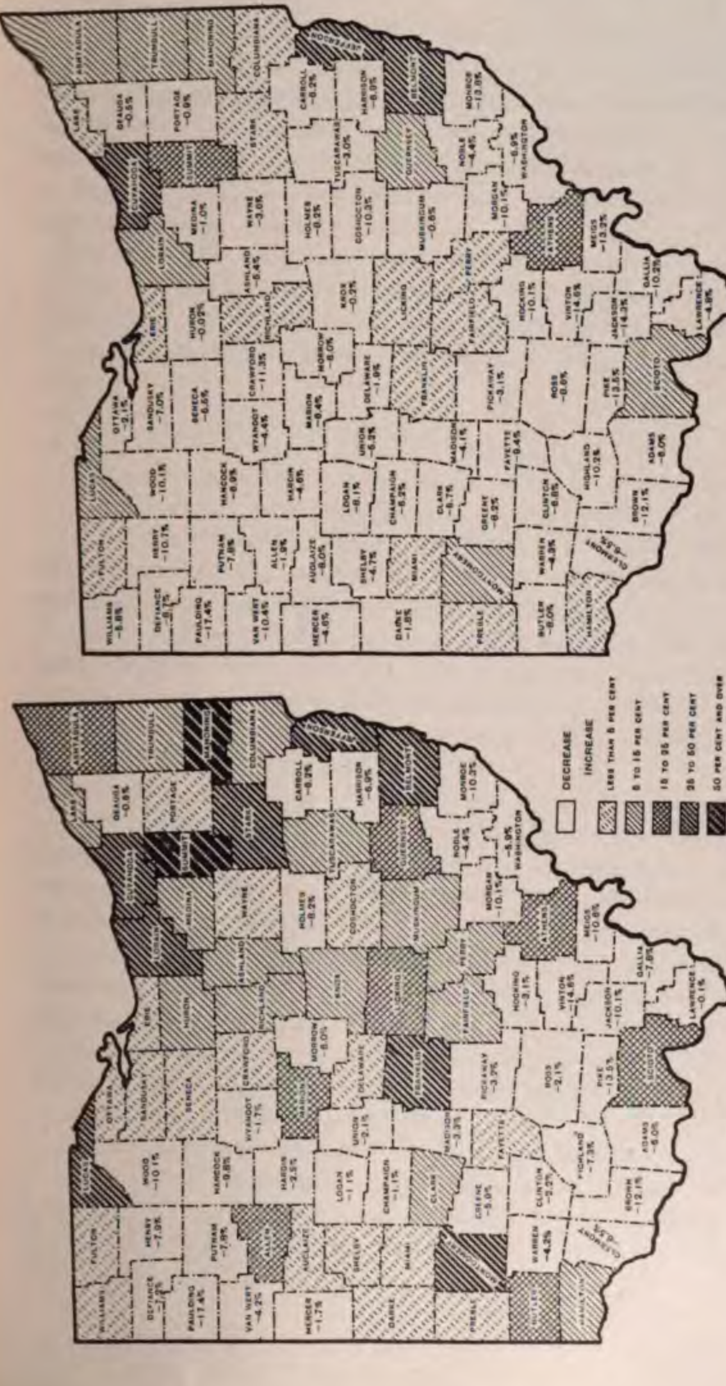
Study census reports showing growth, or decrease, of population. Also school, voting and other records stating population, etc., can be studied later.

Note characteristics and tendencies of growth of principal terminus:

Of secondary terminus.

Of intermediate territory.

Note direction of existing railroad traffic. Why have the roads such directional location? Existing business and social relations



Total Population

Rural Population

FIG. 2.—Per Cent of Increase or Decrease of Population of Ohio, by Counties, 1900–1910.

Rural Population is defined as that residing outside of Incorporated Places having 2,500 Inhabitants or More.

have built up a certain direction of travel and if the proposed road does not serve such existing traffic tendency, what reasons are there for presuming that the direction of movement can be changed? Make note of this to ascertain more accurately later. It requires exceptional conditions to deflect existing direction of travel.

The location of an existing road may have resulted from either through or local traffic conditions.

If the former, and local conditions make a cross country road desirable, then the traffic condition for the proposed road may be excellent, but, in this, as in every other matter, all statements must be carefully weighed and the facts ascertained by investigation.

Inspection of Route and Territory

Being now prepared to appreciate what is seen, a rapid trip over the route is advisable, but not giving too much attention to detail, and not reaching definite decisions. It will be time enough later to consider the equivalent of 5-ft. contour lines; 50 ft. is sufficient at this stage. During such trip intelligent and applicable questions can be asked, and the answers recorded, but not necessarily digested, and certainly not evaluated, until later. Frequently I leave printed forms with bankers, secretaries of chambers of commerce, etc., to be filled in and mailed, or preferably collected and discussed on a return trip.

A return trip can next be made and somewhat more leisurely, and giving more attention to details, topography, character of soil, width of rivers, height of banks and of high water, character and growth of industries, crops (gross and per acre); probable effect of proposed road on character of crops, present routing and market, population, growth and characteristics. Industrial and sociological information of all kinds, bank reports, building loan reports, etc., all are important. In each case comparative statistics extending over a period of years should be obtained—tendencies and direction of growth and especially of decay, should be noted and the reason ascertained.

Present traffic and reason for traffic should be noted. How much of the existing traffic will the proposed road obtain? Probably little, if any, of such traffic as originates or terminates beyond its terminals—probably a large part of that which is local between such terminals.

From information as to amount and direction of traffic and knowledge of general conditions affecting cost of construction and, having considered strategic position, then a tentative location can be considered. If the country is rather rough, a survey of one or more routes may be advisable; if it is comparatively level, the survey may be postponed; when to make survey also depends on time available, the season of the year, and other factors, including advisability of appearing to be busy, and of surveying more than one route in order to obtain interest and competition. This is about the only time when anything will be "given" to the road.

Tentative Plan

The tentative plan will be based on such ruling and maximum grades as the engineer's experience indicates to him will probably prove, after further examination, to be about right, considering magnitude and direction of traffic, topography, etc. Carried along with considerations of locations, grades, etc., will be preliminary studies of the equipment which will be necessary to handle the traffic, and the character of service best fitted to the conditions, and the general type of equipment best suited to the service to be given.

Tentative train sheets should be prepared and comparative advantages and disadvantages tabulated. Effect on platform charges (exceedingly important), effect on total and maximum peak power (as to each substation and as to power house), location of passing points, relation of same to grade, meeting at central points in town, and whether advisable or not, and other items.

The location of power house and sub-stations, of car shops, etc., requires careful consideration.

The business probably obtainable for each class of service—passenger, express, freight, mail, should be estimated on an annual basis, and also monthly. In some cases, the sale of power and light may be contemplated, but these items should be separated from receipts from railroad operation. The probable rates obtainable, expense of operation, including financial and all charges, total investment and net income for the second, fifth, and tenth year of operation, or some other future periods, must be predetermined with the greatest care.

Modification

The next step is consider each general feature and then each detail of each general class and ascertain what changes could be made, and the *net* result, that is, *effect on dividend.*

Affecting Factors

A careful study should be made of the past history, present development and tendencies of the territory, and considered with reference to probable effect on magnitude and character of future growth.

The rules and the apparent tendencies of the decisions of the Interstate Commission and of the Public Service Commission having jurisdiction should be considered.

Not only should location, construction and equipment be considered with reference to the traffic "in sight," but also with reference to the development of the territory, including the possibility of assisting in such development, and, in the latter connection, the character of construction and equipment which will be most desirable if such development is obtained.

The history of the existing transportation companies serving the same territory should be noted and the policies or tendencies of the officers as, for example, whether they have fought or cooperated with other electric railroads along their lines.

Profit or Loss

Profit or loss depends upon the difference between two almost equal amounts.

A very small percentage of difference in receipts or expense will make a *large* percentage difference in the amount available for dividends.

Location, including terminal facilities, will largely affect the gross income and also cost of construction. Character of construction and equipment somewhat affects receipts and largely affects operating expense, including maintenance, depreciation, and accidents.

Importance of Careful Preliminary Investigation

A slight change in location may favorably or unfavorably affect construction cost and gross and net income, therefore, practicaally speaking, it is impossible to give too much time and expenes to a careful preliminary investigation.

The preliminary investigation will frequently indicate that as to the *immediate future* certain locations will cost a comparatively small amount, and that such grades as economically advisable for the traffic immediately in sight can be constructed at slight expense, and that there will be a minimum expenditure for bridges and avoidance of grade crossings of other railroads or highways. It may be possible that such location is also advisable as to the more distant future, including strategical position with reference to business competition; if the grades, bridges, and trestles can be so modified later as to then obtain a road having grades desirable for such future traffic, then the location may be advisable. Probably, however, such will not be the case as to at least a portion of the route, and the future must always be considered.

The Future

Considering the future is not, however, equivalent to building for the future. Planning for the future is advisable, but expending capital in order to provide for the distant future requires careful consideration. It might be better to place such money in a sinking fund, rather than in unproductive construction, Such sinking fund is usually theoretical consideration, the more usual consideration is, "Can such present unnecessary expenditure be saved and the total cost reduced, and thereby the proposition be made more attractive to capital?" Steel bridges vs. wooden trestles are simple examples of such consideration. Future changes of grade will require (at least usually) a greater total expenditure than if originally constructed at such final grade, but, nevertheless, the interest saved is always important and may be vital.

Change in location is always expensive. When the road is proposed much of the right of way has little value and a skillful promoter can sometimes obtain right of way in a new territory for a comparatively small amount. When, however, the road develops the territory, then land becomes worth more to the owner and is likely to cost the railroads on the basis of even a greater percentage of increase.

The general result is that, to a considerable degree, the design and more especially the construction which make provision for the future should be mainly in connection with such items as will require a far greater total expenditure when in the future same are modified or reconstructed than if originally so constructed.

Right of way and especially terminal facilities are free from maintenance and depreciation, and to change, or add to in the future, is very costly. On the other hand, such items as ties, poles, trestles, minor buildings, and rolling stock, require renewal in a comparatively few years and are largely independent as to their functions and usually should be designed with reference to the near future, and the character of replacement allowed to await the development of the business.

System and Data Sheets

When making a preliminary investigation of the territory, a definite plan should be followed. Doubtless all engineers who are experienced in such matters prepare data sheets on which they note such matters as they consider important.

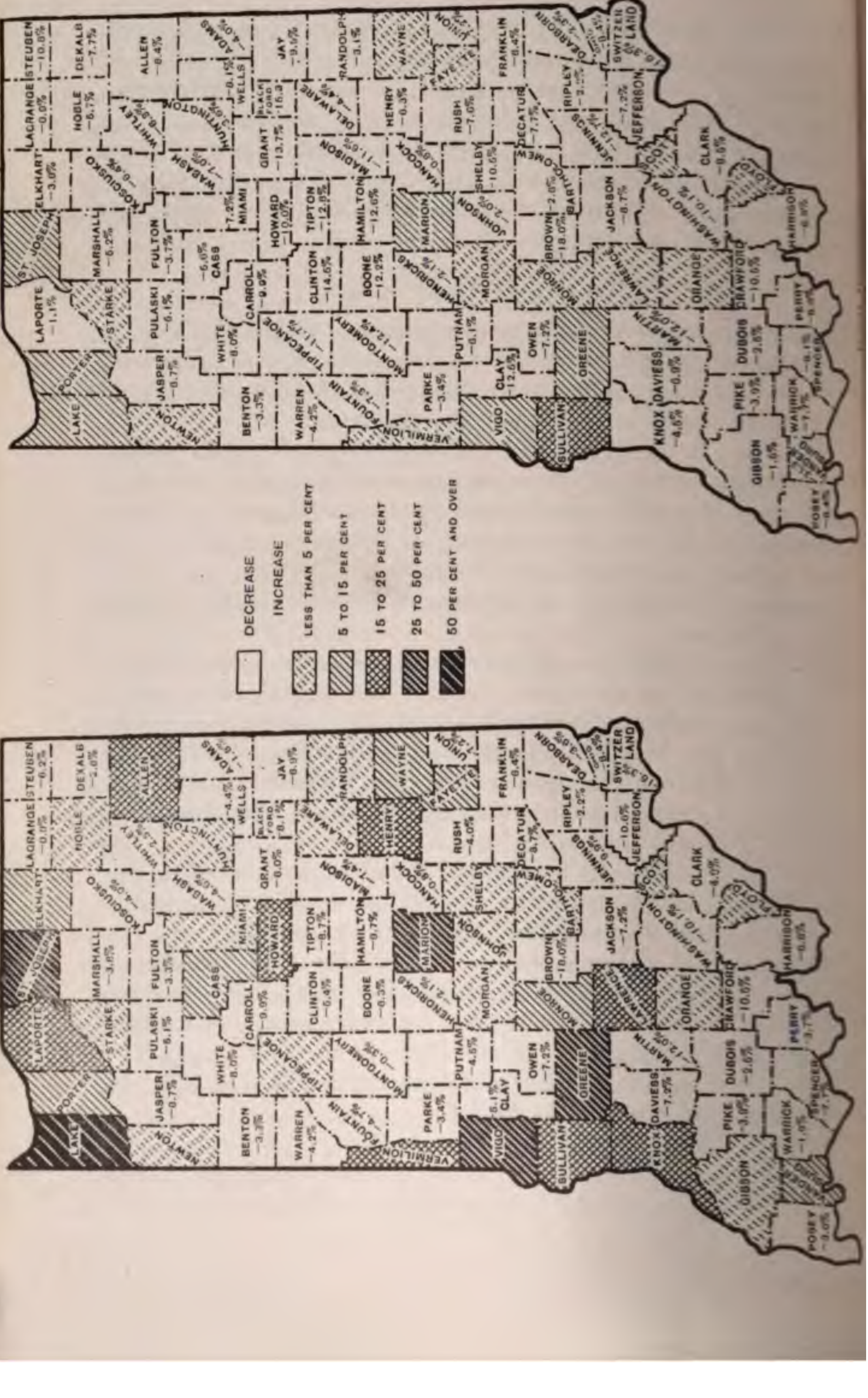
I consider it very advisable to prepare general data sheets, tabular forms, etc., at times of comparative leisure. When a specific case is under consideration the forms prepared are liable to be affected by special conditions and thereby lose general applicability and convenience for comparison.

The general character of information desired can be divided into two classes:

First. That which in a general way always exists. For example: division of territory, into cities, towns, villages, rural, etc.; population and its tendencies; public buildings; public service properties operated by the city or by corporations; educational institutions; churches; theatres; libraries; parks; fair grounds; banks, and building and loan associations; manufacturing establishments; wholesale and retail business houses, etc.

Second. Conditions of an unusual character, such as oil or gas wells, exceptionally large state institutions, manufacturing plants with world wide reputation and having many employees, etc.

The unskilled observer, and sometimes the skilled observer, sometimes neglects to check off his list; he obtains quite complete information relative to the unusual or striking and spectacular conditions and omits some of the items in the first class. The result is that additional money and time is required in order to obtain data, or it is not obtained.


DECREASE
INCREASE
LESS THAN 5 PER CENT
5 TO 15 PER CENT
15 TO 25 PER CENT
25 TO 50 PER CENT
50 PER CENT AND OVER

Data

When obtaining data from individuals considerable allowance must be made. It is well known that locating the high water mark of a stream on the basis of the statement of the "oldest inhabitant" is very unwise. Usually information can be obtained from more than one source and the advisable discount made, and thereby fairly accurate information obtained as to practically all of the major non-technical factors relative to the territory. Bank statements and talks with bankers are very helpful. The country banker has a detailed knowledge of the crops, mortgages, and points to which shipments are made, and as to all of the activities of the rural communities, and his statement can be accepted as

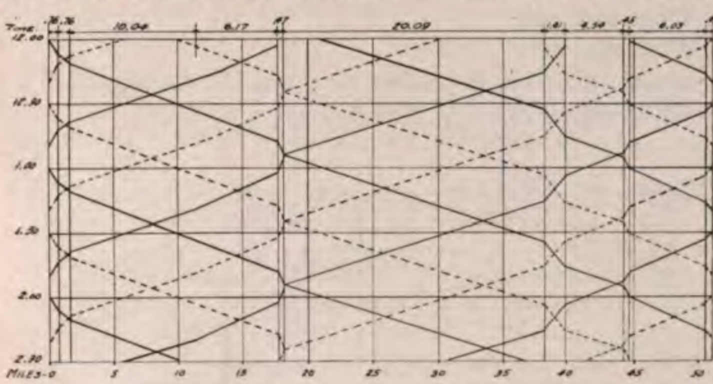


Fig. 4.—Shows Hourly and Half-hourly Headway on a Typical Road.

approximately accurate, especially if checked up in a few cases by examination of a few farms, etc. The conditions of the fences, buildings, etc., usually indicate the facts as to mortgages.

The application of general statistics to a specific case may be helpful, but is always accompanied by the serious danger that the figures may be used which should not be applied to the case under consideration.

Statistics can be obtained as to roads in the same general territory, and possibly having the same principal terminal town, and these should be considered carefully. No statistics from any road should be applied to the proposed road unless the engineer has quite complete knowledge as to the road from which the figures were obtained. No two roads are exactly alike and, as before

stated, it must never be forgotten that a very slight difference in the net receipts may make the difference between profit or loss to the stockholders.

Existing Properties and Properties Other than Interurban Electric Railroad

Earlier in the evening I stated that I would consider the preparation of reports relative to existing properties and to properties other than Interurban Electric Railroad—time only permits a brief statement.

As to existing properties the questions which must be answered are:

1. What is it now?
2. What was it?
3. What will it be, if present development continued?
4. What might it be, if development modified?

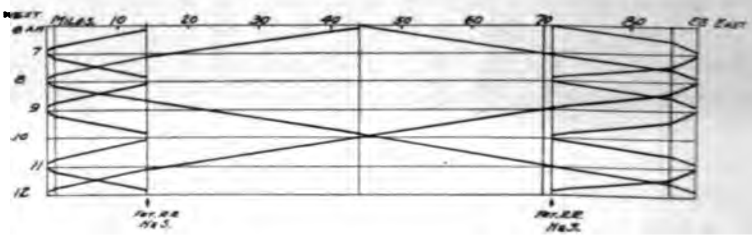


Fig. 5.—Headway proposed for a Road of somewhat Unusual Character.

The preceding paragraph applies to Public Service Properties, and also to manufacturing or other producing properties, the fundamental questions are "What and why—now and future?"

Statistics

For detailed statements, curves, etc., relative to use of statistics in connection with interurban electric railroad, see paper by E. P. Roberts, "Electric Railways in Sparsely Settled Communities," Trans. A. E. Ry. Assn., Oct., '06.

Lantern slides were presented to illustrate points referred to in the paper.

To illustrate the importance of "percentage," tables were shown of gross revenue and gross expenses and the percentage of each item for steam railroads—the percentage of revenue from freight (the large item for steam roads), passenger (the large item for electric roads), etc., and the percentage for fuel, for "platform" charges, etc.

To illustrate the usefulness of census reports, a map showing all the interurban electric and steam railroads in Ohio and Indiana was compared with maps of such States prepared by the census bureau showing the increase and decrease of population, total and rural, by counties.

It was stated that, in a general way, the histories of the interurban roads indicated that the growth of traffic had been best in growing sections, although there were some exceptions, due to special conditions. The latter exceptions show that for the purpose of comparison all factors should be known. A careful study based on all obtainable statistics is exceedingly interesting and of great importance.

The three slides above mentioned are reproduced. Figures I, II, and III.

A slide of a topographical map, prepared by the U. S. Geological Survey was shown and the usefulness of such maps, especially for preliminary investigations, was described.

Several slides of train sheets for interurban roads were shown. The roads having different operating conditions. Short sections of two are reproduced, the names being omitted.

Fig. IV shows hourly and half-hourly headway on a typical road.

Fig. V is for a proposed road of somewhat unusual character. The road is to be approximately 88 miles long, running east and west. At each end is a city of considerable size and they are not directly connected together by a steam road. Each city has a town a comparative short distance away (ten to eighteen miles) and direct, but not frequent, steam road service between the city and the neighboring town. Each of the terminal cities, and each of the towns above mentioned, has a north and south steam road. Between such towns is a rich agricultural country, with numerous villages, which are from 5 to 20 miles distant from any railroad.

The train sheet provides early trains from the country and suburban towns *to* the city and hourly suburban service between each

terminal city and the nearby town during three hours in the morning, at noon, and late in the afternoon and early evening. The balance of the time two hourly.

The through passenger service and the local passenger service for the rural section is not expected to be heavy, and, therefore, four hour headway is provided. The principal traffic in such central section will be freight—live stock, grain, fruit, garden truck, and coal, in train lots. The outgoing freight will originate each side of the center and go to the nearest steam road. The passenger service provides a clear track for such freight movements. The grades are also designed to favor the outgoing freight.

Relative to the consulting engineer keeping informed as to cost figures, slides were shown of data sheets used by the writer for such purpose, and showing in detail labor and material "on the job."

Also the advisability of systematic records and the importance of preparing alternative plans was illustrated.

A map of a road and the tributary and surrounding territory was presented, and how to ascertain what would be the tributary territory and how to evaluate same was dwelt upon. The effect of rivers, high hills, etc., pointed out. Also existing railroads and passenger service on same, its inadequacy and why it would not pay such roads to materially improve same.

Other slides illustrating the visualising of plans, ascertaining cause and effect as affecting traffic, etc., were presented.

Paper No. 1140

AN ANALYSIS OF THE BENEFITS OF ELECTRIC DRIVE IN CEMENT MILLS

By THOS. H. ARNOLD

Read June 6, 1914

In the consideration of this subject the rapid growth of the cement industry, and the magnitude of the power consumption, should be thoroughly comprehended. According to the statistics of the United States Geological Survey there were produced in the United States in the year 1913, 92,097,131 barrels of cement. A fair average of power consumption for the entire country would be 18 K. W. H. per barrel. Thus the cement output for last year represents the use of approximately 1,658,000,000 K. W. H. Of course, much of this is generated by the cement companies themselves and a large portion does not appear in the form of electric power.

The Lehigh Cement District comprises a series of mills along the outcrop of a deposit of Agrillaceous limestone which has very nearly the correct chemical composition as it comes from the quarry. This deposit extends in a practically straight line from Reading to Martin's Creek with a detached outcrop southeast of Phillipsburg, N. J., upon which three plants are operating. This district, in 1913, produced 27,079,000 barrels or a trifle less than 30% of the total for the country as a whole. On the basis of 18 K. W. H. per barrel, this represents a power consumption of approximately 487,500,000 K. W. H. The greater portion of this power was used by steam engines either direct connected to line shafts or transmitted by belt or rope drive to line shafts from which the individual machines were belted.

With a total power consumption of this magnitude, the possibilities for effecting economies are quite vital. Power economies in this industry will have a much wider effect on the ultimate cost than in many other processes in which the power system has been

worked out in very fine details. Very few manufactured products have a higher proportion of their total cost represented by the cost for power as does cement.

The ratio of the power to the total cost will vary widely with the type of machinery and design of the plant. The character of the materials, the labor cost, and transportation charges will also

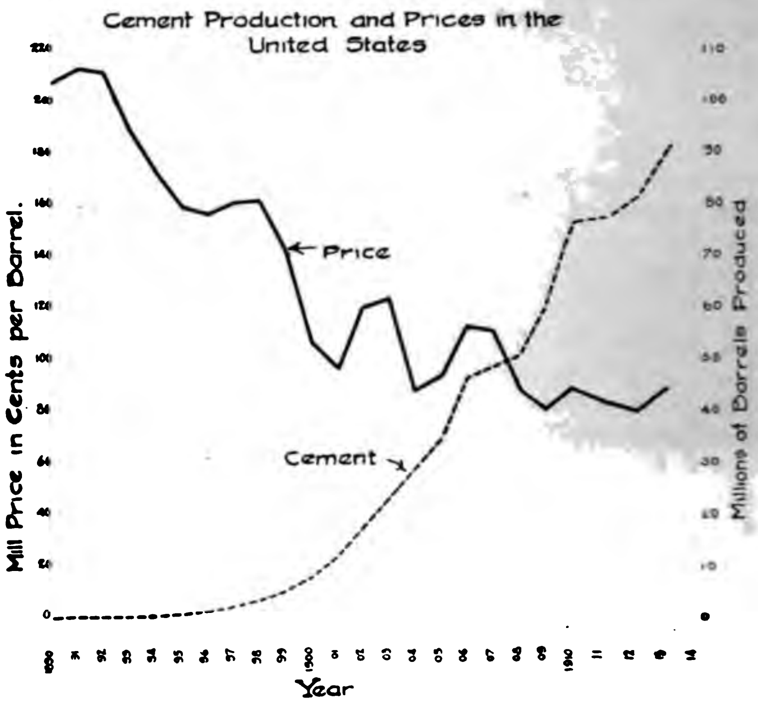


FIG. 1.—Chart of Production and Average Mill Price for Cement Manufacturered in United States.

have their effect on shifting the ratio of the various charges. However, a fair average of a modern mill may be expressed as follows:

Manufacturing labor	21%
Maintenance and repair labor	7%
Supplies	15%
Coal	27%
Office and miscellaneous charges	4%
Power	26%
	100%

Thus the power cost will usually represent from 20 to 40% of the total cost of the finished product, thus power savings will markedly reduce the total manufacturing cost.

The daily load factor is usually very good in a plant of this kind as the mill is run full blast for twenty-four hours per day and seven days a week for about nine months. The winter months will probably average less than 50% operation. Thus the yearly load factor will be in the neighborhood of 60%. With careful management and extra machine capacity this can probably be increased to 80% and by maintaining a steady output in the mill with a large seasonal storage, it would be possible to reach 90%. The

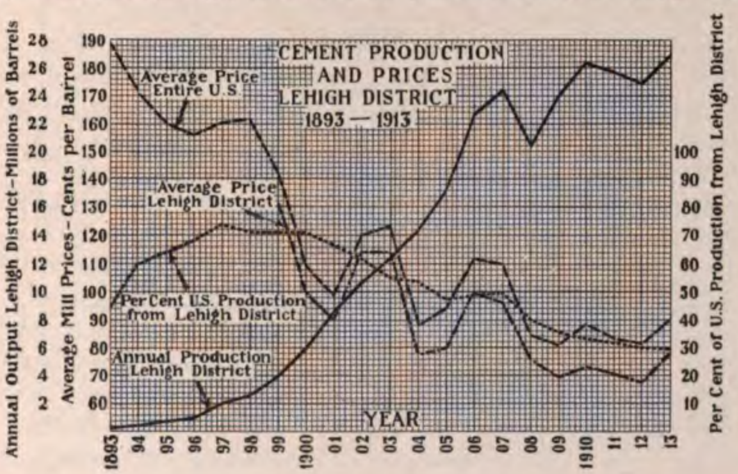


FIG. 2.—Chart of Production and Average Mill Cost of Cement Manufactured in the Lehigh District.

season at which the heavy demand for power occurs would suggest two possible combinations upon which a power company could base a low rate for this class of load. A large city lighting load reaches large peaks in the winter and drops off in the summer. The cement plant demand is the reverse and reaches its heaviest demand in July and August. Many hydro-electric plants have surplus water which could be turned into power during the spring and summer. For this they offer a secondary rate, usually somewhat lower than the regular rates. To induce a cement company to purchase power a very low rate must be offered as the majority of plants are located at a point where fuel is comparatively cheap

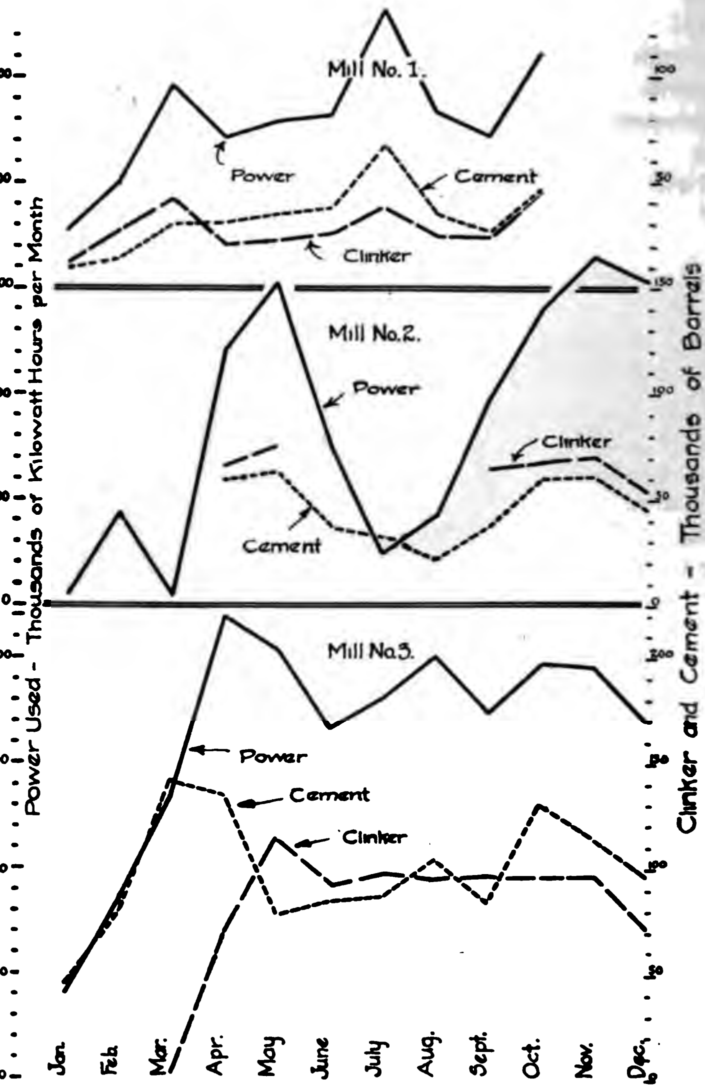


FIG. 3.—Chart of Typical Power Consumption and Cement Production in Electrically Driven Cement Plants.

and with the large units in use and high load factor, power can usually be made at a cost comparing favorably with the average Central Station of similar size.

In the application of electric drive to cement mills, certain conditions must be recognized which are peculiar to this industry. The greater part of the load is in use nearly the whole of the twenty-four hours. The quarry crushing and packing departments are customarily operated for only ten hours. The tendency in some districts has been to run full blast for nine or ten months and shut down partly or entirely for two or three. This gives a rather poor yearly load factor, in spite of the good monthly load factor for the greater part of the year. On a process of this kind, where the power cost enters so largely into the total cost, the yearly load factor should have considerable attention. By running the plant to secure a uniform load throughout the year, some changes will be necessary in the plant. The matter of storages for equalizing the flow of material through the mill will be more necessary. The power charge per K. W. H., with the present rates, will vary with the number of kilowatt hours used in proportion to the maximum demand. Thus to keep the cost per kilowatt hour down we must run with the least possible maximum demand and the largest number of kilowatt hours. This means that as the crushing and packing departments are shut down at night, other load in the shape of extra mills in the grinding departments should be thrown on to keep the power demand at the same point; also extra mills should be provided for use when it is necessary to cut one out for repairs. In most cases with existing equipment this will be taken care of by the extra output available with the electric drive and actually a smaller number of mills will be required for the present output. This method of running for a steady power load will be found to possess numerous advantages outside the saving in the power cost.

It will be noted that in the operation charts of the three mills shown no attempt was made to keep the production and power consumption uniform. Where the power charge is made upon the basis of a fixed charge per kilowatt of maximum demand with an additional kilowatt hour charge, the result in the case of Mill 2 would result in a very high charge per kilowatt hour. This extra cost for power would justify the interest on a large amount of material carried in storage. Operation in this manner must neces-

sarily cause wide fluctuations in the manufacturing costs. During such prolonged shut downs on the raw side and the quarry, the working force would be badly disrupted and in many localities difficulty would be encountered in obtaining a new force when operations were resumed.

The inter-dependence of the machinery must not be lost sight of in the general plant layout. The elevating and conveying machinery is the very life of the plant and should be made as absolutely reliable as possible. Unless the conveyors are installed in duplicate, a shut down for any cause means a shut down of the

Fig. 4.—Ball Mill with Individual Motor Drive.

whole section of the mill ahead of it. In this way a properly designed motor drive will eliminate many causes for shut down due to shafting, belting and friction clutch troubles.

Starting loads are unusually severe. The machinery is heavy and more especially the ball and tube mills require very large starting torques in proportion to the running load. For this service the wound rotor type of motor gives excellent satisfaction. The Fuller, Griffin, Kent, and other mills do not require such heavy torque unless they are shut down with a load in them. Of course, theoretically, this should not be done, but practically in the opera-

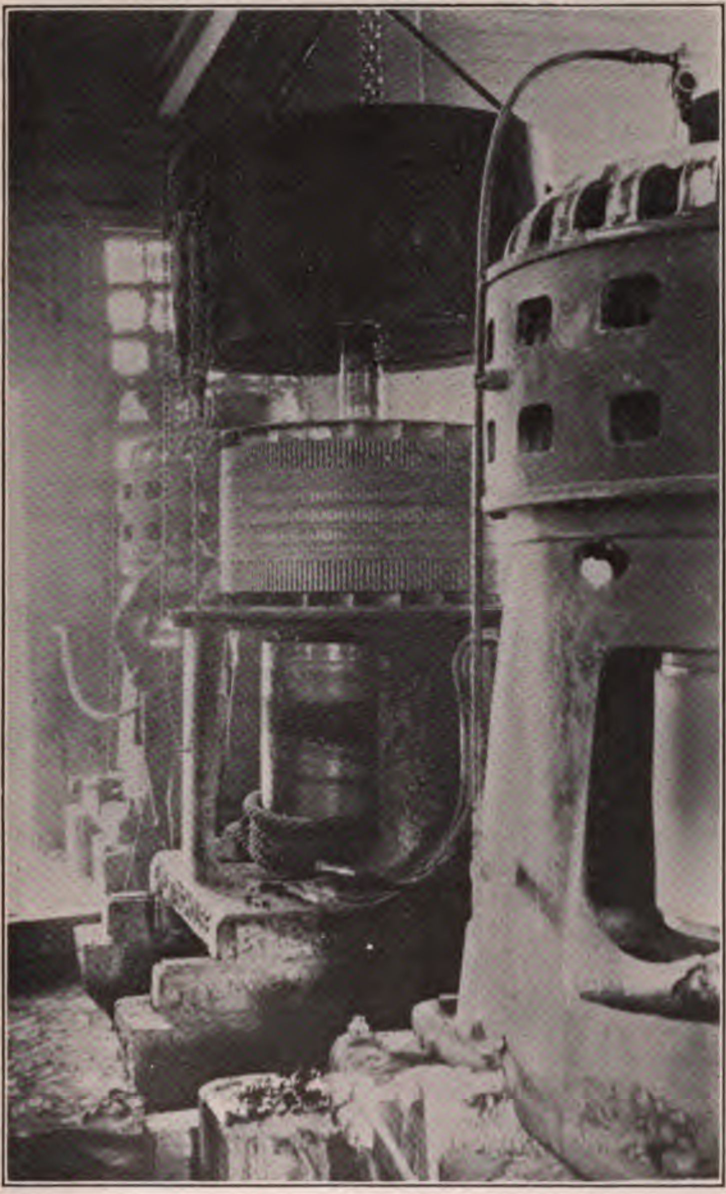


FIG. 5.—Belted Type of Vertical Motor showing General Construction.

tion of the mill these things are done and have to be taken care of. The motor is expected to pull out a choked elevator or conveyor, and if it will not do so it is considered the fault of the motor itself. These conditions have resulted in applying many features of special design to the motors for this service. Some of these features have been incorporated to better the design of standard lines of motors.

As in other industries new machinery has been developed for carrying out special features. Mills of the Fuller, Emerick, Griffin, and Bradley types with a vertical shaft have called into use a vertical type of belted motor in fairly large units. These are used in sizes from 50 H. P. to 200 H. P. With the application of pulverized fuel in the steel and copper industries, these mills have a much wider application in grinding coal. Thus the special machine of a few years ago becomes the standard machine of today.

The use of the magnetic pulley for separating iron from the coal or rock before it passes to the grinding machinery is becoming more common as the saving in mill repairs due to this machine becomes more widely known. Electricity is used to a large extent for operating scales and counters in weighing the material in transit. Hoisting and hauling problems and the application of electricity to drilling and rock shovels have been tried out in the mining field wherever large quantities of material are handled. The special features of the cement industry in this line are very similar and no more severe than have been met in the mines.

Recently the value of the storages in the various stages throughout the plant is being appreciated. Several types of machinery have been tried for this service. In the earlier storages the capacity was small and the belt conveyor, the bucket elevator and conveyor were ample. It soon became apparent that the maintenance cost was very large, especially on the clinker storage. The Monorail hoist and high speed electric traveling crane then made their appearance. These are capable of handling large tonnages in a short time at a very low cost. However, special precautions must be taken to protect the moving parts from the abrasive dust.

In the smaller plants probably a Monorail system with a grab bucket of sufficient size that it could tend the rock, coal, and clinker storage would prove ideal. In the larger plants the individual cranes for each storage would prove more satisfactory.

The condition of dust and dirt are peculiar. Electrical apparatus is designed to operate under comparatively clean conditions.

When dry, cement dust is a rather good insulator, but when wet it absorbs moisture like a sponge. For this reason there is very little to commend the practice of installing overhead transmission lines around plants of this nature. The use of a pressure above 600 volt is not usually considered advisable in industrial plants unless special precautions are taken for protection. This means that with the heavy power consumption, large conductors must be installed. The cost of the structures necessary to support these conductors will approach very closely the cost of an under-

Fig. 6.—Vertical Motor Installation driving Fuller Mills.

ground system and will not be nearly as satisfactory. The strains are enormous and as the coating of cement gets thicker the ordinary sleet and wind calculations are exceeded. Frequently No. 8 weatherproof wire will build up two inches in diameter and stretch out until it breaks from the weight of the accumulation. Large cables must be periodically cleaned of the accumulation or the structures supporting them will be damaged. The leakage in wet weather will amount to a very considerable item. This is more noticeable as the voltage is increased. At one plant a 2,300

volt line ran from the power plant back of the mill and over the hill. This line was exposed for about seven poles to the action of the cement dust. After this line was in place about two years, trouble was encountered. In wet weather the leakage could be observed at night and in about six months the pins were digested and had to be replaced. The current frequently flashed over and blew 40 Amp. fuses at the power plant when there was no load on the line. In the Lehigh district this trouble has been encountered on power lines located two and three miles from the nearest mill.

Most of our switching and circuit breaker apparatus is not designed to meet the severe dust conditions. Frequently the abrasive dust works into the movable parts and prevents switches and circuit breakers from operating properly. In some cases they have to be dismantled before they can be opened or closed. This dust is a very good heat insulator and as the ability of a motor to carry its load depends largely upon its ability to get rid of the heat generated, unless this dust is frequently removed, trouble on this score may be expected. The most popular method of taking care of this trouble is to pipe compressed air from the quarry compressor around the plant, and to use a hose for the removal of the dust. This distributes the dust in a great cloud throughout the building and results in a general exodus of the operating crew till the air has cleared. A better method would be to take all possible precautions to prevent this dust from escaping.

Unless carefully watched the dust will accumulate in the bearings and in many cases the dust around the outside of the bearing will siphon off the oil and leave the well dry. The remedy for this is, of course, obvious. With ring oiled bearings provided with proper dust guards the trouble from cutting of the bearings is not so troublesome as might be expected as the stream of oil constantly washes away the abrasive matter. Pulleys and rotors are likely to get accumulations of dust around the circumference. When they are shut down this will all fall to one side and if not cleaned out is likely to throw them badly out of balance.

Unless very liberally designed and well-fitted, clamp contacts, enclosed fuses, knife switches, and similar apparatus will give trouble. This dust will gradually creep in between the surfaces and form a poor contact. With the resulting heating, conditions are likely to get worse instead of better unless proper remedies are applied. Some forms of movable contacts when left standing open,

especially in the presence of oil, are coated with an insulating covering which will cause arcing and burning when closed. Meters are usually specified to be "dust proof." However, with this impalpable powder we find that nothing but hermetically sealing will give such a result. The meters are more or less delicate and in some cases the dust accumulation inside them will seriously affect the readings. In case the glass is cracked or the case damaged, the meter should be repaired as soon as possible.

It is undoubtedly true that a much larger percentage of costly

Fig. 7.—Vertical Motor Installation driving Griffin Mills.

mistakes have been made from unfortunately chosen electrical machinery than in any other part of the mechanical equipment of cement plants. This has resulted from the fact that the electrical equipment was considered a minor factor and hardly deserved serious attention, thus the machinery was not in all cases carefully selected to fit the requirements. These troubles may be largely overcome by a careful consideration of the detailed requirements of the individual plant before and during the drawing up of the plans. Each plant should have a careful analysis made by an engineer thoroughly conversant with the needs of the machinery.

In this way both construction and maintenance costs will be kept at a minimum due to the thorough method in which all points were considered in the original planning and erection of the machinery.

With a plant properly designed we may expect many advantages with the electric drive which do not exist in the steam driven plants. As a rule the matter is considered very little deeper than the saving in the cost of power itself. That there will be a real saving in power cannot be denied. In a number of cases the fact that several

Fig. 8.—Storage Tended by Monorail System.

electric driven plants have shown a high horse-power consumption per barrel in comparison with some of the steam driven ones has been widely commented upon. But in these comparisons we have largely lost sight of many elements which have a very considerable bearing on the power consumption. The electric driven plants have mostly been in the West where the material is vastly different and finer grinding is more prevalent. The power consumption of some of the electric driven mills in the East have been given so low that the figures have been discredited and yet figures very little higher on steam driven equipment using similar materials

are pointed out as reliable results which may be accomplished with an economic steam plant.

The elimination of the transmission machinery, large clutches, bearings, heavy pulleys, shafting, and intricate rope and belt drives, are bound to effect more of a power saving than will be lost in the electrical machinery necessary to replace it. The efficiency at partial load will be very much better. In this connection the possibility of arranging the drives in such a way as to be able to utilize the power to the best advantage will be given more atten-

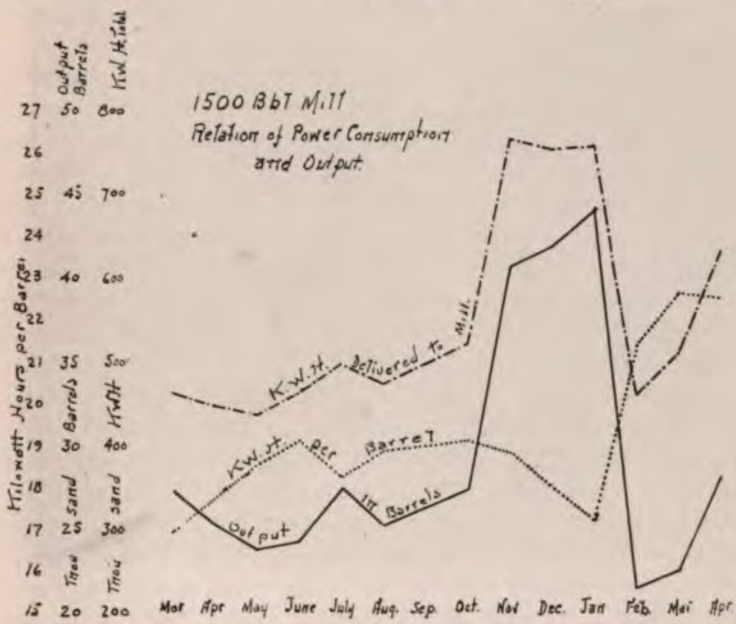


FIG. 9.—Chart showing Relation of Power Consumption and Cement Output in an Electrically Driven Mill.

tion, and as the use of purchased power becomes more common, the advantage of a good yearly load factor will be better understood. By operating in this manner, the working forces will be kept together and new crews will not have to be broken in as is usual after a shut down. The overhead charges are spread out over a more uniform production and thus the variations in production costs are largely reduced.

In a steam driven mill the boiler plant is usually located in some central location unless the plant is large enough to have several

boiler houses. In this case, we have the option of running some long steam lines to supply engines at the far points of the mill or we can run long rope drives. Either method of installation is costly from a construction standpoint and wasteful and expensive on the operating side. These losses are frequently overlooked in running power tests on the steam machinery. These tests are usually made by indicating the large engines, thus omitting power used for pumping at detached points.

Repairs are reduced to a minimum with electric drive. The modern alternating current motor is probably less subject to break-down under normal running conditions than any other piece of transmission machinery we have at our disposal at the present time. What repairs are necessary are easily made and inexpensive. The shut down need not be long and in the worst cases the entire replacement of a motor is neither a lengthy nor costly operation. Where several similar motors are required a spare unit will frequently save its cost in shortening the shut downs by replacing the machine in need of repairs and enabling the repairs to be made at a more convenient time. The extra capital tied up need not be large if due care has been expended in a careful standardization of the equipment. That this can be done is readily proved. In an individually driven plant with some seventy-five motors, of which some were specially designed for the purpose, the writer was able to keep within ten sizes of alternating current motors and two sizes of direct current. The advantage in thus keeping to a few standards is quite apparent from an operating standpoint and will soon offset any saving in original cost, in the simplification of the repair parts necessary and the small time loss of making changes. This will be more apparent, of course, under Western conditions where an express order means from ten to thirty days and freight is usually figured at two or three months. However, even a matter of a day is important when machinery is expected to grind away as nearly twenty-four hours as possible.

Belts and ropes for driving are short lived at best in cement mills. In a great many cases a year's run is exceptional, even on some of the heavy drives. Leather belting is increasing rapidly in price and in a few years its use will be almost prohibitive under these conditions. Various forms of cotton belting have been devised and some of them seem to stand up to better advantage than leather when cost and life are considered. The total belting ex-

pense for a year on some of the plants would go a long way toward paying for the electrical motors necessary to drive the machinery with a system of individual motors.

The elevators and conveyors call for many small units of slow-moving power supply at detached points. To meet this demand various forms of geared motors have been tried, some of which were not successful. In the earlier experiments the gears were run open and were exposed to the rapid collection of dust and dirt which caused a short life and high maintenance cost. In many of

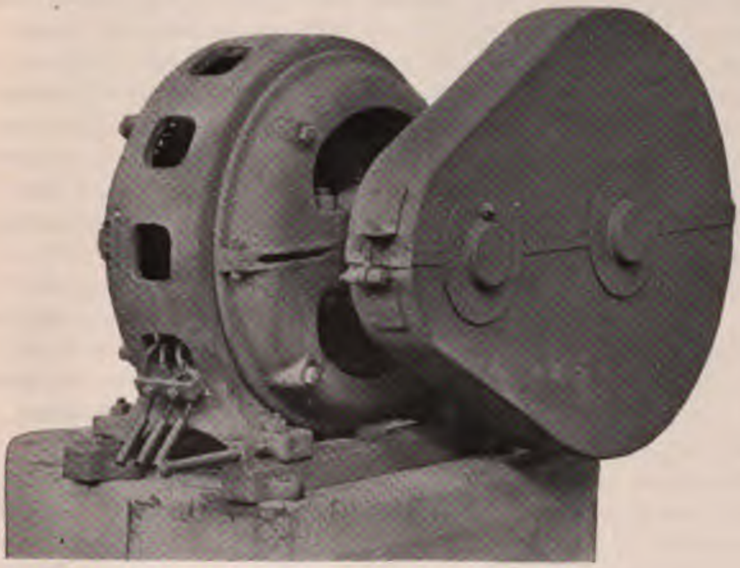


Fig. 10.—Back Geared Motor with Enclosed Gears.

the earlier types the motor and the shaft were on separate foundations and were apt to work out of line which added to the trouble.

From these failures have been built the sturdy back-geared motor with the cased gears running in an oil bath. This unit requires a minimum of attention, has a long gear life and will have less cause for shut down than a countershaft belt drive. From the safety standpoint very little remains to be desired. In the out of the way places, in which these motors must be placed, the footing is apt to be poor and open shafting and belting is a constant source of danger. With all moving parts cased as shown a man could

fall all over this motor with nothing but bruises for his carelessness. When the cost is considered the saving by putting a countershaft and pulleys in place of the back gear will usually be lost in belt maintenance in the first year of operation.

Heavy shafting, clutches, and pulleys are expensive to maintain. The expense is doubly felt because it is necessary to shut down large sections of the mill in order to make repairs. The other machinery remaining non-productive while the damaged parts are being replaced. In comparison the repairs to electric machinery are much less frequent and the expense is almost negligible. The defect of interference with the operation of large sections of other machinery does not exist. The quantity of oil and grease which is required with the line shaft drive is greatly reduced with motor drive. A higher grade of oil is used but it lasts much longer so that the total cost will be but a fraction of that previously required. A great saving may be expected from the fact that the depreciation on electric machinery under these conditions is much less than on transmission machinery with the line shaft drive.

A much larger output may be expected from the existing machinery with individual motor drive. A number of causes will contribute toward this and we will proceed to take them up in detail. Probably the greatest of these causes will be the greater percentage of mill hours run due to the additional flexibility in operation. A mill may be cut out for repairs or general repairs may be made on the system without interfering with the running of other units. Very few plants with engine drive can show a long run on any department without a shut down of the engines to repair some portion of the transmission machinery. These shut downs may not be of long duration, but they seriously affect the mill hours run. If we have, say twenty grinding machines belted from a line shaft and we shut down for one hour, we lose the equivalent of twenty hours on one machine. The actual time shut down frequently does not represent all the time lost by the mills, as some time is usually required for cleaning the mills of feed and in getting the feed running full again. Where several short shut downs occur during the day they will cause a very serious interference with the output.

A considerable increase in output will be noticed, due to the steady speed obtained by the elimination of belt slip. A careful test will ordinarily reveal the fact that with a belt driven plant it

is almost impossible to maintain the speed on the machines at the most efficient point throughout the entire mill. The correction of

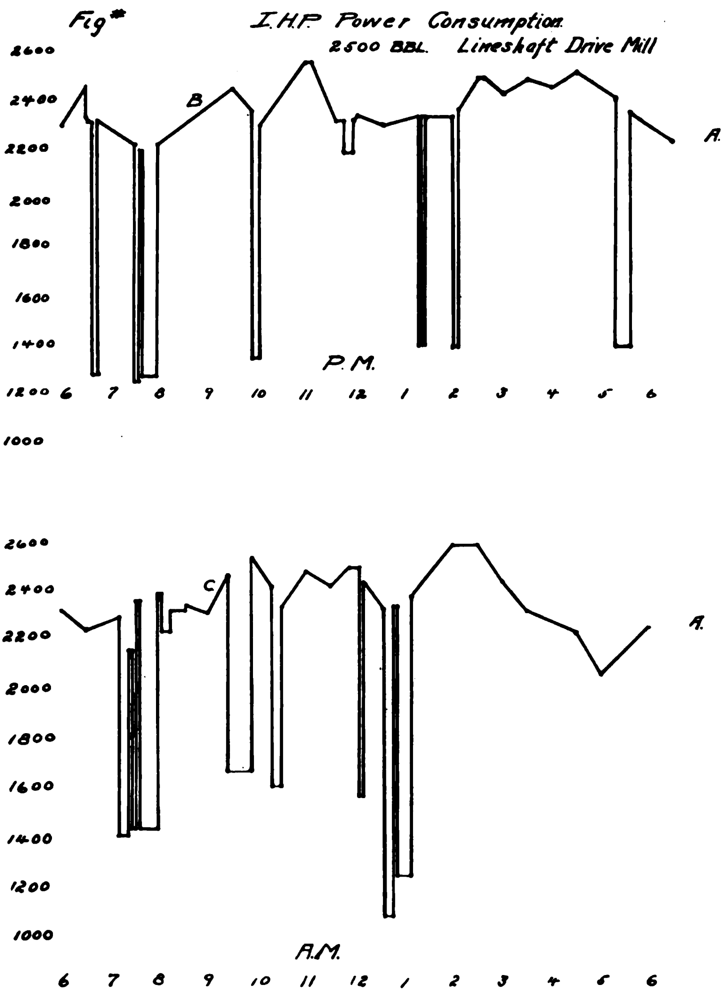


FIG. 11.—Typical Power Consumption Chart in a Line Shaft Driven Mill Chart made from a Series of Indicator Cards taken on the Various Engines at short intervals.

this feature will, as a general rule, increase the output from five to fifteen per cent.

The ability to study the exact power and output conditions in each machine will lead to a further investigation of why the power and output of some of the mills seem to vary. The point of maximum economy in a mill is thus easily determined and maintained.

The introduction of individual ammeters on the motor control panels will enable the operators to hold the mill at its best operating point more readily than by judging as to the feed. By watching the ammeters carefully, defects in the machine are readily noticed and the machine may frequently be cut out in time to avoid serious damage. This method for actually measuring the work done by the machine instead of guessing at it has been known to increase the output by five per cent.

The motor drive also introduces greater facilities for starting, stopping, and obtaining changes in speed. As a rule, with motor drive the change of speed involves only a change in a rather small inexpensive pulley or gear. Where several different speeds are to be used the variable speed motor offers a much more convenient method than any mechanical device. The upkeep costs on the various mechanical devices of this nature are quite large. In operating the kilns, a more uniformly burned clinker and a larger output can be secured, with a variation in the speed of rotation to suit the material inside the kiln. The reason being that the heat conditions can be regulated with a greater nicety by retarding or accelerating the speed at which the material advances against the flame than in trying to regulate the flame itself. A combination of both methods should give the best results.

When changes are contemplated in the existing machinery, the line shaft must be considered first, last, and all the time. Motors may be installed practically anywhere and in any position. The first consideration is the requirement of the grinding machinery. The floor space may be used to better advantage and less complications are involved in alterations and additions.

The increased importance of the trend of legislation toward compensation of workmen for injuries should not be overlooked. While this matter may not at present have much effect in some localities no one can predict how soon it will be advanced or how far it will be carried. In some States these matters have to be carefully considered, on account of the numerous damage suits, and the legal and contingency account may be several cents per barrel. The omission of the line shaft, belts, and clutches goes a long way toward reducing the causes of accident.

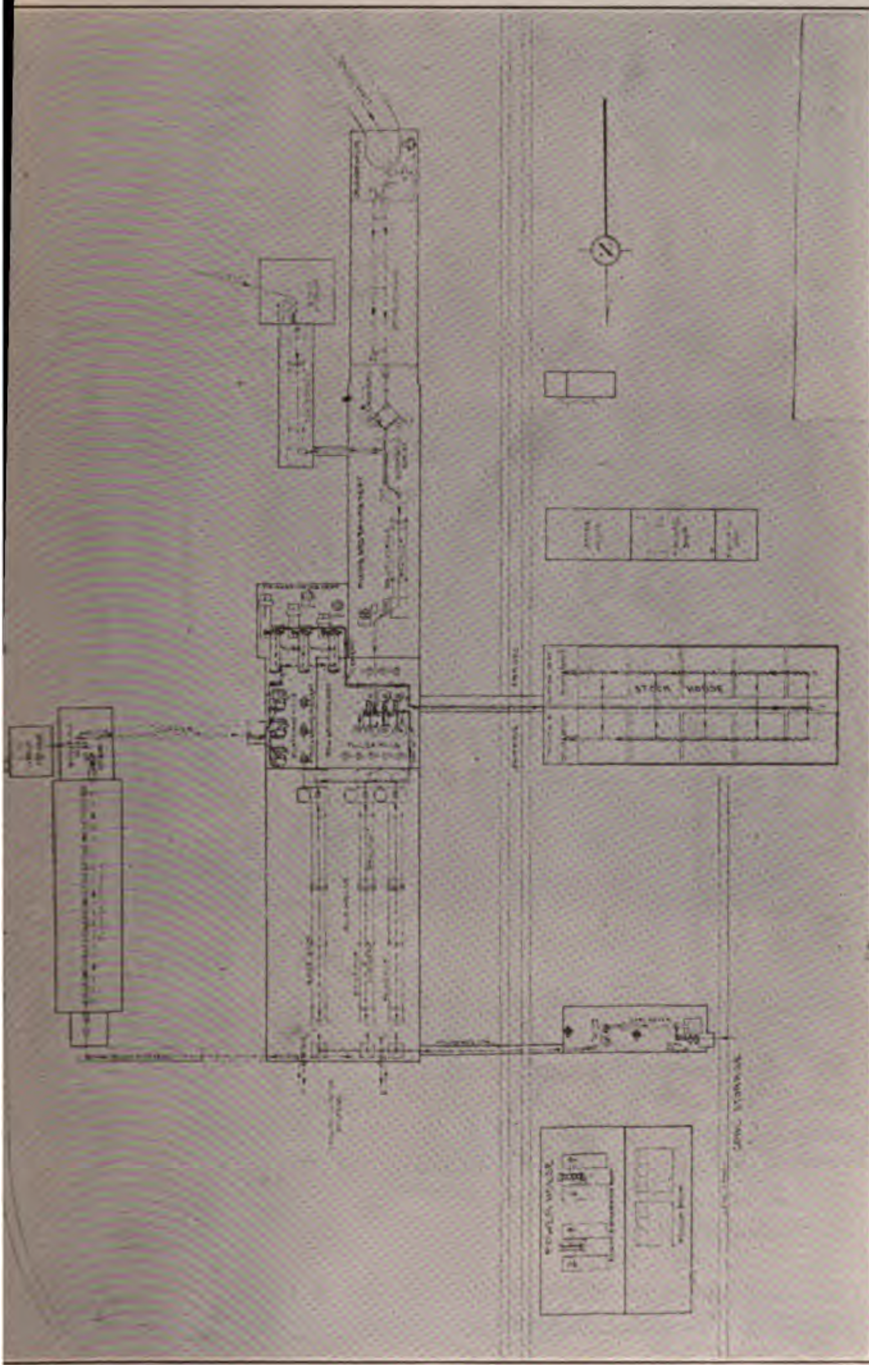


Fig. 12.—Plan of a Cement Mill showing the adaptability for making Additions to the Plant.

The power house may be placed away from the dust of the mill and thus the machinery kept in better shape. The capital outlay for power plant may be considerably decreased by the use of steam turbine equipment. The opportunity to eliminate the power plant entirely should not be neglected. The power plant is almost always a rather bad point. It frequently introduces difficulties of its own entirely foreign to the cement industry. Purchased power will usually result in a considerable saving and eliminates one source of worry for the superintendent. He will thus be able to devote his time and energy more closely to his real work which

FIG. 13.—Steam Turbine Power Station for a Cement Plant.

should be the operation of the mill to produce a maximum amount of cement at a minimum of total cost.

A very good example of the advantages to be obtained by the proper selection of the electrical machinery will be shown by analyzing a modern mill. This mill is located in the West and due to the quality of materials and other local conditions the arrangement is considerably different than would be the case in a more favored district.

In the general layout of the plant, the topographical restrictions did not present serious difficulties, although they could probably have done so with a purely steam drive. Concrete was used as

largely as possible in the construction of the plant. All buildings, bins, and even the roofs were made of this material, and it was even carried to the extent of laying concrete walk-ways between the buildings. The wisdom of this course will be at once apparent from an advertising standpoint as well as utility. The construction cost was somewhat high, but the maintenance cost is practically nothing.

The center line between two railroad tracks through the plant form the datum line from which the buildings were laid out. Each department was housed in a separate building and all were planned for an ultimate enlargement to take care of five 8′x150′ kilns. The flow of the material through the plant is direct from one process to another with due storages to take care of fluctuations and no crossings or interference.

Power is transmitted through underground cables from the power plant which is located away from the dust and dirt of the mill. The power plant is an instance of the saving in investment and operating cost to be obtained from the use of the steam turbine and electric drive. Two turbines of 750 K. W. capacity furnish the power, thus giving economical operation when the mill is cut to half capacity. In this case very poor water was to be had for boiler feed. In fact 26 grains of total solid per gallon was about as good as could be expected. As the impurities were partly in suspension a water treating plant was installed which removed about fifty per cent. of the total solid. The remainder was sodium chloride, sodium sulphate and calcium chloride and sulphate, making their removal rather difficult. The power plant thus offered a great many difficulties of an entirely foreign nature to the manufacture of cement and this company would gladly have purchased power had any such been available. Frequent trouble was encountered from foaming in the boilers and numerous slugs of water went through the turbines, sometimes seriously interfering with their operation. On the whole the turbines stood up under this kind of treatment rather better than could be expected of reciprocating engines.

The crushing department was rather simply arranged. The material in hand loading sizes was brought from the quarry in two-yard narrow gauge cars and dumped into a pair of No. 5 Gates' crushers and elevated to a pair of 24″x36″ Buchanan rolls, bringing the material to half-inch size. From the rolls it is carried to

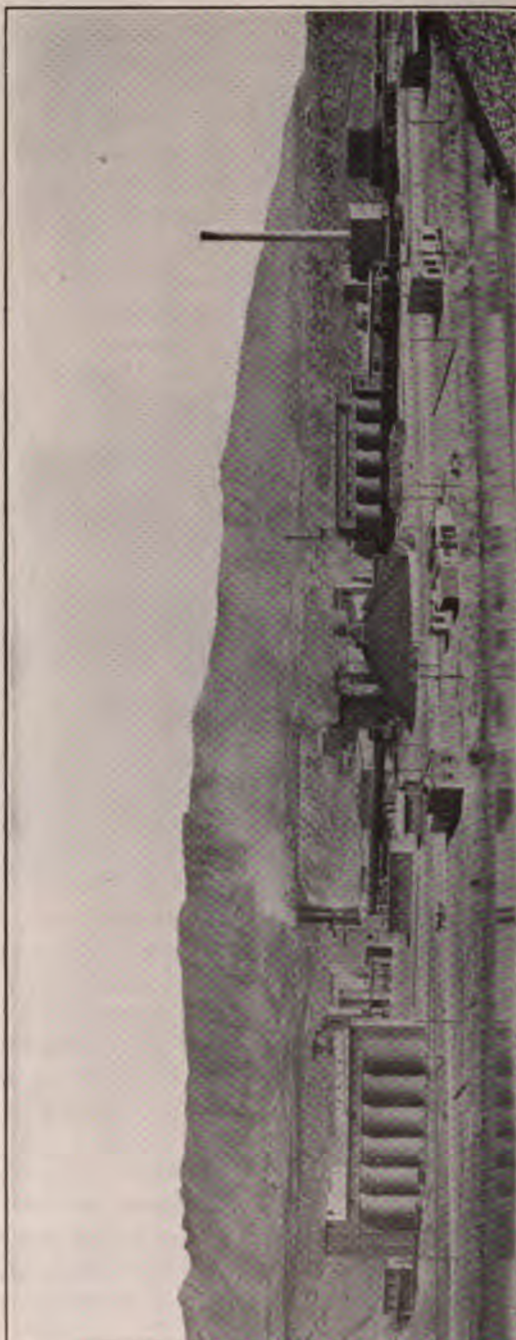


Fig. 14.—General View of Plant.

the crushed rock bins and was sampled on going into the bins. From these the material was mixed and weighed into the blending bins. The raw mix was finally made from the blending bins and passed through the drier to the Fuller mill feed bins in the raw grinding department.

The raw grinding department consisted of eight 42″ Fuller mills, each belted from its individual 75 H. P. vertical motor. The installation was ve y compact and quite efficient in every way. The mills were placed four in a row, all feeding into a conveyor

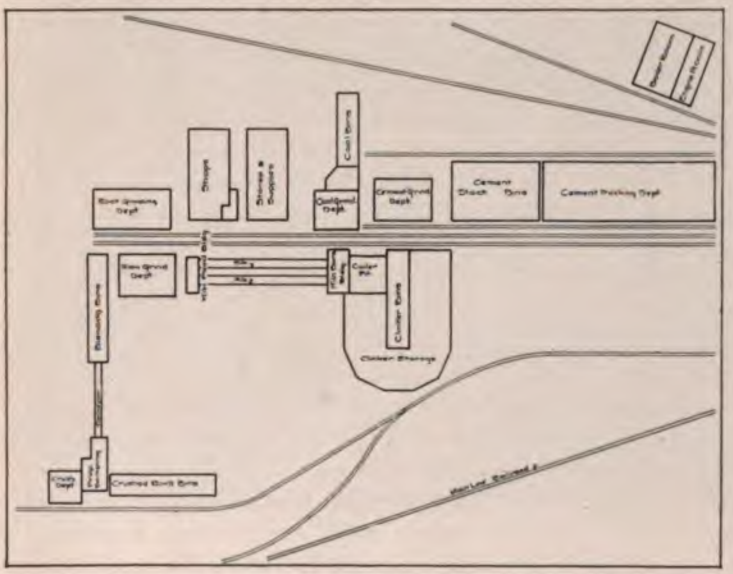


Fig. 15.—General Plan of Electrically-driven Plant.

between the rows of mills, thus utilizing a minimum of space and a short conveyor. Each mill is a unit in itself and any number can be out of service without interfering in any way with any of the others. The belting is cut to a minimum and no heavy line shaft transmission machinery is necessary. Repairs are slight and a high percentage of mill hours is attained.

The material, from the time it arrives in the kiln feed bins, is entirely under the control of the burner without necessitating his leaving the burning floor. Variable speed motors are placed on the raw feed of each kiln, on the kiln itself and on the two coal

feed screws of each kiln. The controllers for these motors are arranged in a convenient manner at the front of each hood along with the auto starter for the rotary cooler. The fan motors are on this same floor. The clinker passes from the kilns through the rotary coolers and is elevated to a storage of about 80,000 barrels capacity.

A clinker grinding department is very similar to the raw grinding. A set of 24x36 Buchanan rolls, operated by 30 H. P. motor, crush the clinker to half-inch size. The gypsum is introduced at this point. Both clinker and gypsum are weighed on automatic scales. Quarry run gypsum is used. This is reduced in a Jeffrey hammer mill belted to a 20 H. P. motor. The large pieces apparently present no difficulty and the power consumption rarely goes beyond 25 H. P. for momentary peaks and more frequently it is in the neighborhood of 10 H. P. From the rolls the clinker is elevated to the bins. The grinding equipment consists in six 42″ and two 54″ Fuller mills. The 42″ are belted direct to 90 H. P. and the 54″ to 150 H. P. vertical motors.

In general all elevators, pivot bucket carriers, conveyors, etc., are belted or geared to individual motors. The lighting is carried entirely separate from the power mains. A lighting cable being run to central transformer stations and 220 V 3 wire or 110 V 2 wire mains run out as the case may be. Probably ninety per cent. of the wiring is in conduit. While the first cost of this class of work is somewhat high, it may be said that the small portions of exposed wiring caused more trouble than all that enclosed in the conduit. The cost for maintenance and repairs, including mill power plant never becomes a serious factor in the cost per barrel. This was, of course, under conditions of rather high labor cost and where the freight sometimes equals the factory cost of the parts. It also included the greater part of the services of an electrical engineer whose services would not be considered necessary in a mill of this size in the East.

A large amount of experimental work was carried on with a view of improving the process and cutting the cost. In work of this nature the results are much more satisfactory as the electric power enables accurate records of power consumption to be made. The cost of the experiments are much less on account of the small cost of the transmission equipment and the fact that even if the experiment was not successful the equipment used was largely standard and could be used in other places.

The percentage of mill hours was high, although more attention was paid to load factor at the power plant than to mill hours. In fact, the power plant was not sufficient to pull the surplus mill machinery if it should all be thrown upon it. As the equipment was shut down in one department the power was taken up in another.

A large factor in this plant was the safeguarding the men. The laws of this State are such that corporations are very subject to damage suits in case any workmen are injured. We all know that

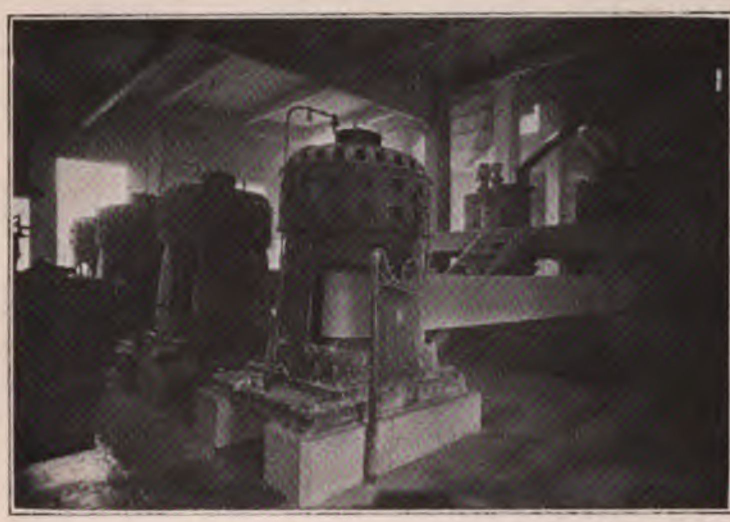


FIG. 16.—Fuller Mill Installation driven with Vertical Motors.

many more of the legislatures are taking up these matters and no one can say how far it will be carried. In some cases the damage suits run several cents per barrel on the entire year's output. This is a case where an ounce of prevention is worth several pounds of cure. The electric drive eliminates largely the line shafts, belting, clutches, etc., which are usually the cause of many accidents in these plants. By making more compact units, railings may readily be placed around the moving parts. One large advantage is that where electric drive is used the engineers are very apt to make frequent tests. This brings them frequently into portions of the mill which otherwise are not apt to get much attention from

the high-class talent of the plant. Thus things are observed and remedied which otherwise would be left to the repair gang's good mercies.

At this point, I wish to bring out one point which has been called to my attention. This plant had a poor power factor. This was largely due to the fact that a number of the early type of slow speed vertical motors were used. In fact, this is one of the first plants to be equipped with this form of motor. Many of the defects in the early types were eliminated in the newer motors due to co-operation between the plant management and the electrical manufacturers. In this case the power factor was not a serious item as the generators and distribution cables had ample capacity to take care of the extra current. The load factor on the contrary was very good and this has probably been confused in the lay mind with the other term, which is of less importance.

It may be said that this is all very well in a new plant, but how about a plant now operating with a line shaft drive? Will it pay to make the change?

The situation should be carefully analyzed and comparisons made with electrically driven plants. There is very little doubt that money wisely expended for electrical equipment will pay a much better rate of interest than the investment in the plant as a whole. In many cases the saving per year would amount to as much as 50% of the investment required for making the change.

Paper No. 1141

POWER PROBLEM IN THE LEHIGH DISTRICT

By HERMANN V. SCHREIBER

Read June 6, 1914

Three important factors contributing to the development and growth of a modern industrial community are the natural resources available, the cost of delivery of product to a profitable market and the cost of power. The section of southeastern Pennsylvania, from Allentown to Easton and vicinity commonly known in the cement world as the Lehigh District, is usually well favored in these respects, and as a consequence has grown rapidly for the past twenty years until it is today a community of unique interest from an engineer's standpoint.

Beginning at New Village, N. J., about ten miles east of Easton, this district extends westward along the Lehigh Valley past Bethlehem to Allentown, thence northward along the Lehigh river to Slatington, and is about ten miles wide and thirty miles long. Twenty-five cement mills with an annual output of 27,100,000 barrels of cement per year are located in this district.

Not content with this valuable industry, there are in this district some of our largest iron manufacturing establishments, like the Bethlehem Steel Co., at South Bethlehem, the American Steel & Wire Co., at Allentown, and the Ingersoll-Rand Co. and the Taylor-Wharton Steel Co., near Easton, besides numerous silk mills, knitting mills, and many other industrial establishments.

According to the 1910 census, we find that these establishments are large consumers of power and that within the limits of the principal cities of the district mentioned there is installed about 100,000 H. P. divided among the varied industries outside of the cement industry. The cement industry alone has installed about 100,000 H. P. more, making a total installed plant capacity in this district of something like 200,000 H. P.

North of the cement district there is a slate district which also requires a considerable amount of power in small units for pumping, hoisting, and manufacturing slate products. There is no doubt but that the natural growth of these districts in the five years since this data was secured has resulted in a 10 to 20% increase in power required.

Still further north lies the well known anthracite coal district which produces almost all of the anthracite coal mined in this country. The electric power which may be used in mining coal

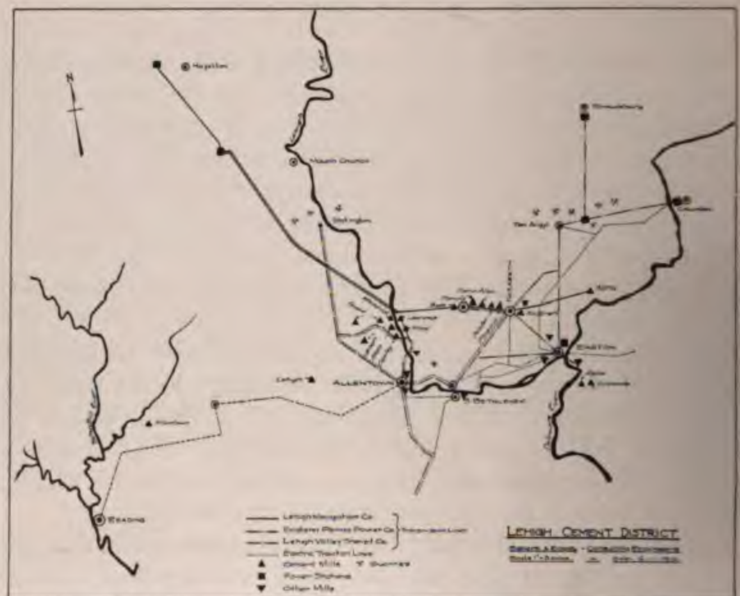


FIG. 1.—Map of Lehigh District showing Transmission Lines of various Power Companies and Location of large Power Consumers.

varies roughly from three-quarters to three kilowatt hours per ton and the results which seem to have attended the electrification of the coal mines in such States as West Virginia, Virginia, and Colorado suggest that in mining the 75,000,000 tons of coal in this district every year there is a good opportunity to use large quantities of electric power.

In the past, the power required has largely been developed by steam at individual plants and in view of the proximity of the

anthracite coal district, power costs have not been excessive. To deliver this fuel into this district the canals were first used, both along the Lehigh river and the Delaware river, but for many years their use for this purpose has largely been superceded by steam roads which can quickly deliver the coal from the mines direct to the power user.

With the more recent development of the district, however, there have sprung up, as in other districts, several methods of delivering electric power as a substitute for direct development of power by steam by each individual user. Gradually this method

Fig. 2.—Hauto Sub-station of Lehigh Navigation Electric Co.

of development has centered about Easton as one centre and Allentown as another with transmission lines radiating throughout the district for delivering power to a rapidly increasing number of users. The result is that today there are installed at and near Easton in connection with the Eastern Pennsylvania Power Co. a total approximate capacity of 25,000 kilowatts feeding a district north, east and south of Easton, and almost to Allentown on the west.

At Allentown there has been developed a plant having a total capacity of 35,000 kilowatts with lines continually extending in

all directions until they have reached a total of fifteen miles to the north, twelve miles to the east and south along the Philadelphia interurban line. Only very recently have these systems supplied

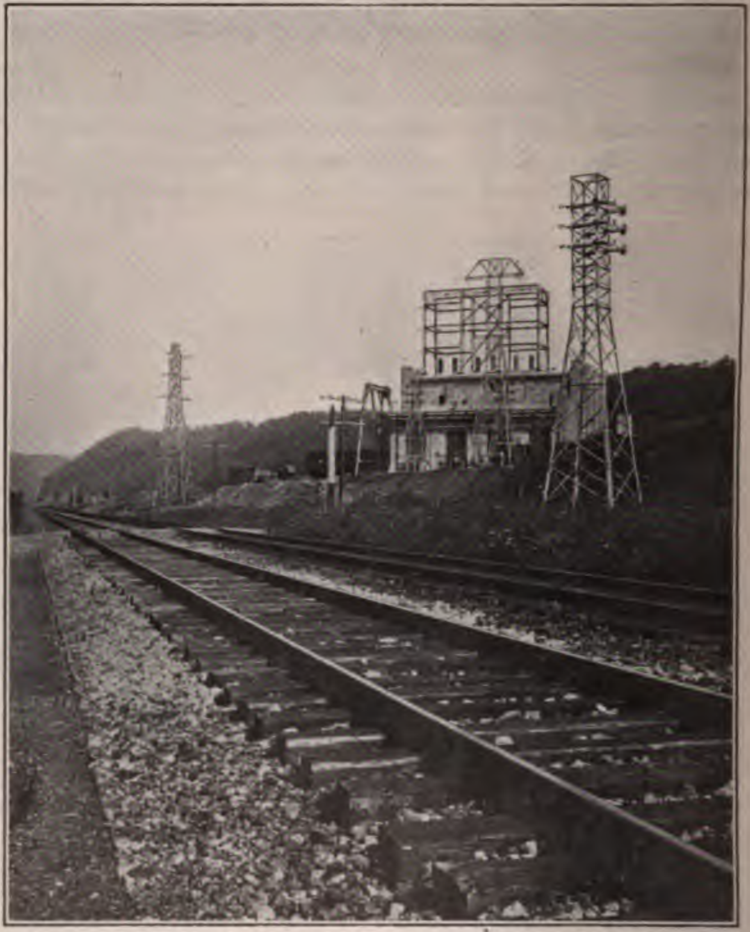


FIG. 3.—Siegfried Power Station of Lehigh Navigation Electric Co.

the larger power users, though they all appear to have picked up a very profitable business from the smaller and more miscellaneous users of power and light. The development of the Interurban Railway System has added to the power demand and the lines extend-

ing to Philadelphia have provided opportunities for developing a power business in this direction which no doubt will prove quite profitable in the future.

As the railroads superseded the canal in the delivery of fuel to the great advantage of the users, so there is in this district an interesting illustration of the way in which the electric transmission of power may in turn supersede the use of the railroad to the still greater benefit of the users.

For years the value and usefulness of the large banks of culm and anthracite slack which were piled at the mouths of the different coal mines, have been a constant source of speculation, and as a concrete example of the way in which they can be utilized to advantage, the recently developed plants and systems first of the Harwood Electric Co., and later of the Lehigh Navigation Electric Co., which feed into the Lehigh district are good examples. The latter feeds directly into this district, and located at Hauto about twenty-four miles north of Allentown, there has been built a power house with all auxiliaries, which in time will be capable of developing a maximum plant capacity of 100,000 kilowatts. Besides using a relatively small portion of the capacity for operation of the various processes connected with the production of coal, this plant is delivering power into the Lehigh district for the operation of cement mills, is negotiating for the delivery of power to the Allentown plant, and by its substantial duplicate transmission lines is placing itself in a position to supply a large portion of the power market in this district.

Both the Hauto plant and the Siegfried substation of this system include the very latest devices to guarantee continuity of service and efficiency of operation. While the system has been in operation only a few months there is every reason to expect that the service will be entirely satisfactory to the long distance user, and by promoting the electrification of cement mills and other industries will do much to increase the efficiency and profits accruing from the operation of all the industries in this district.

Not only is this district rich in its raw material resources and close to a liberal fuel supply, but there are along the stretches of the Delaware and Lehigh rivers, within easy transmitting distance, approximately 100,000 water horse-power, which, when the cost of development can be justified, will be an important factor in

further developing the district. The present conditions along these streams, however, without regulation, with railroads close to the river level, and without especially attractive sites for large unit developments, are not such as to appeal to those desiring to develop power at this time. These water power possibilities have been studied for years, a few developments have been made and when such storage projects as are suggested by the New York State Water Supply Commission on the upper reaches of the Delaware become feasible the developments further down-stream will be worthy of more serious consideration. The general character of the flow available is indicated by the stream flow duration curve which is included herewith.

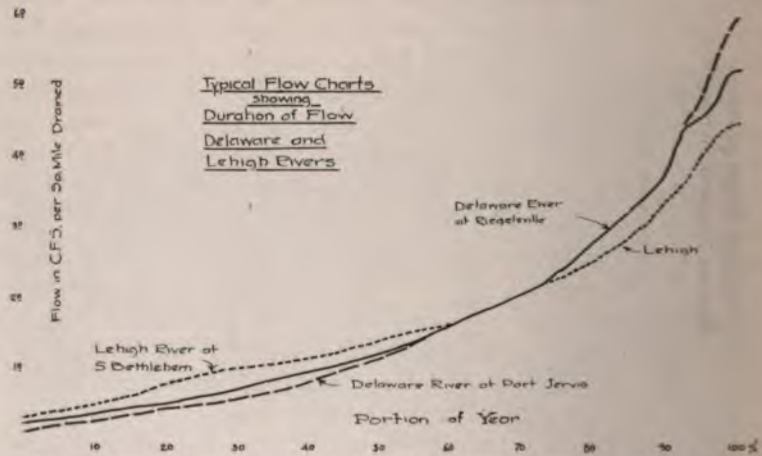


FIG. 4.—Stream flow chart for Lehigh and Upper Delaware River.

As previously stated, about 50% of the power used in this district is used for the manufacture of cement. This industry is growing very rapidly and furnishes the possibility of an almost ideal load for a central station. The load is about uniform throughout the twenty-four hours and Sunday shutdowns do not occur. The slack season occurs in the winter when the demand is usually greater in other lines. Thus a load of this character will do much to raise the load factor on a central station. In an industry in which such large quantities of power are used, it is natural that the power should be used in such a manner that the total power cost will be reduced to a minimum.

The following curves are shown for purposes of illustration of the principles applying in estimating costs of purchased power:

In Figure 5, Curve A, the kilowatt hour consumption for a cement plant is shown by months. We will assume that this plant

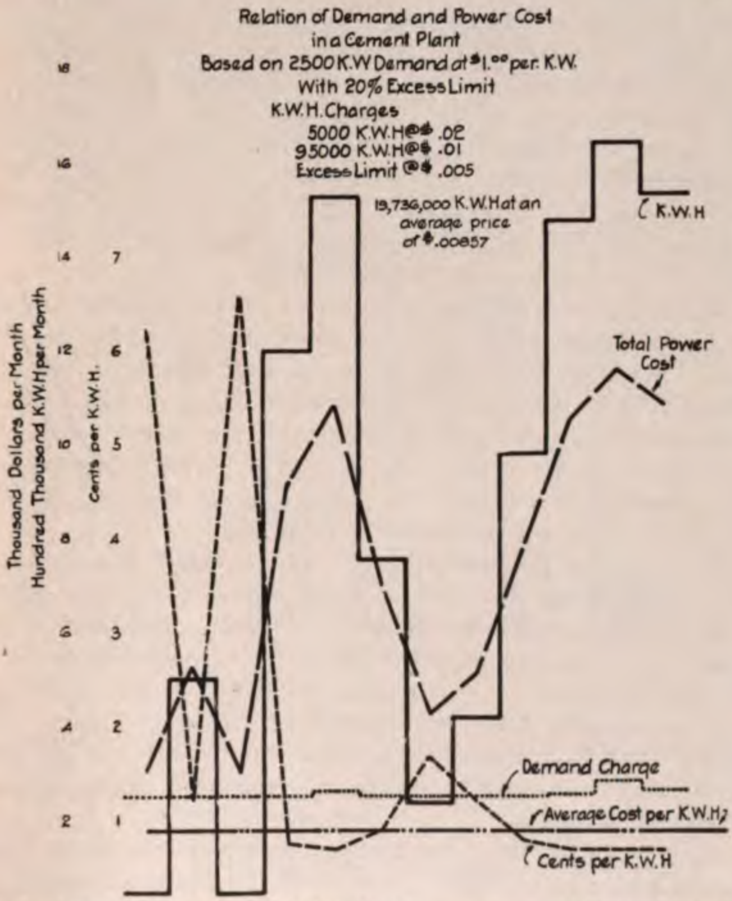


FIG. 5.—Chart of Relation of K. W. H. Consumption and Power Costs in a Cement Mill.

was buying power on the basis of a demand charge of $1 per month per kilowatt of maximum demand and that the contract demand must not be exceeded by more than 20%. In addition to this charge a kilowatt hour charge according to the following schedule is added:

First 5,000 K. W. H. . . . . at $.02
Next 95,000 K. W. H. . . . . at $.01
Above 100,000 K. W. H. . . . . at $.005

The demand charge will be shown by curve B and it will be noted that the greater portion of the year the charge is made on the basis of the minimum contract demand. Curve C shows the K. W. H. charge added to the demand charge, giving the total cost for power for each month. While this curve in general follows the power consumption it does not follow in direct proportion. This is shown by Curve D, which gives the actual cost per K. W. H. for each month. This varies from a maximum of 6.55c to a minimum of .707c per K. W. H. with an average cost of .857c per K. W. H. for a total of 19,736,000 K. W. H.

Figure 6 gives a similar set of curves for ten months' operation on another plant which used the power demand to better advantage. It will be noted that the variations in demand as shown by Curve A were much less. The demand charge in Curve B was greater than the contract minimum for one month only. The cost per K. W. H. varied very much less. The maximum being 1.57c and the minimum .715c. The average cost per K. W. H. was .805c for a total of 8,023,870 K. W. H.

In comparing the two plants, it will be noted that the second plant while using less than half the power of the first actually bought its power .052c per K. W. H. cheaper. Had the first plant operated in a similar manner it should have reduced its power bill by $10,263, or 11.6%. In reality, the average price should have been considerably lower than the cost for the smaller plant. Both plants could have materially reduced the average cost for power by utilizing their clinker and cement storage capacity to the fullest extent.

These notes, covering the general power situation in the Lehigh district with suggestions on power costs, are presented with a view toward aiding those interested in the problem of reducing the manufacturing costs. The savings secured by economical use of purchased power emphasizes the importance of a uniform power demand in order to obtain a minimum power cost. The methods of determining these costs are radically different from those in vogue in individual plants. The usual form of power contracts are clear to those familiar with this class of work, but are at first

somewhat confusing to the average mill superintendent. To get the lowest ultimate cost all elements must be carefully weighed and balanced and the mill operated in such a manner that this balance will be maintained.

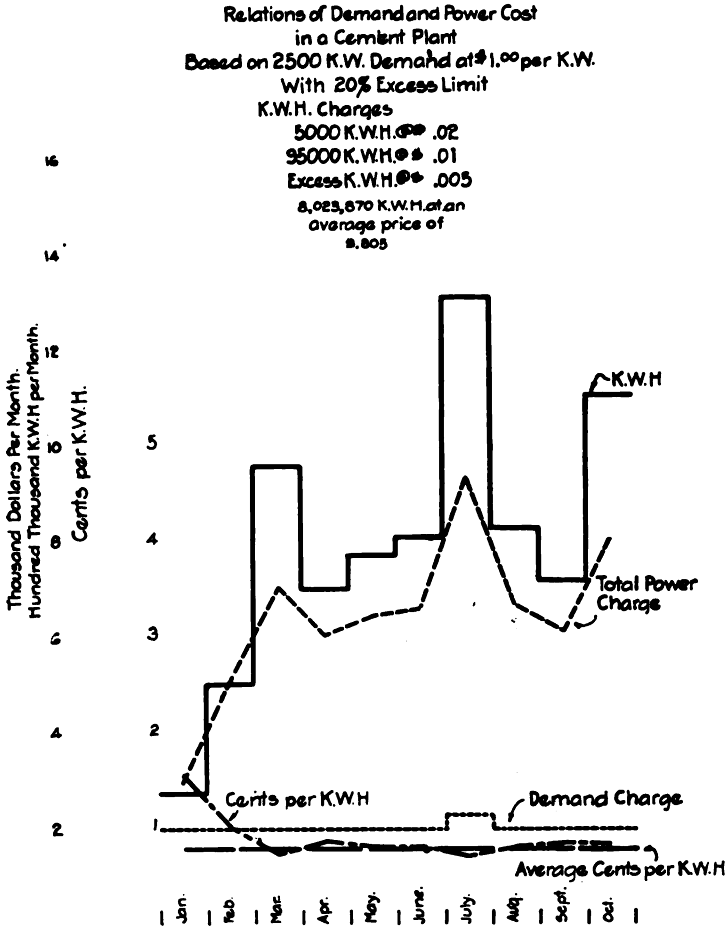


Fig. 6.—Chart of Relations of K. W. H. Consumption and Power Costs in a Cement Mill.

ABSTRACT OF MINUTES OF THE BOARD

Regular Meeting, April 14, 1914

As no quorum was present, the President ordered a Special Meeting of the Board to be held on Friday, April 17th, at 12 o'clock noon.

Special Meeting, April 17, 1914

Present: President Swaab, Directors Haldeman, Yarnall, Gibson, Worley, Berry, Dunlap, Andrews, the Secretary, and the Treasurer.

The minutes of the Regular Meeting of March 17th were read and approved.

The Treasurer reported a net loss to April 1st of $37.17, as compared with a net gain for the same period of 1913, of $1,618.77.

The Membership Committee's report was presented and the following were elected: To Active Membership, Harry Bortin, Fred W. Fernald, and Frederic Merrick Gardiner; to Associate Membership, O. C. Gilbert and William Ralph McLain.

The Secretary reported that the ballots for the election of Colonel George W. Goethels and Benjamin Smith Lyman to Honorary Membership had been received and that their election was unanimous; and that Mr. Lyman had already accepted his election.

The Treasurer was authorized to strike from the books the dues for the year 1914 of Mr. A. E. Harvey, Jr., who died in February, 1914.

Mr. B. A. Haldeman was appointed a delegate to represent the Engineers' Club at the National Conference on City Planning, with power to appoint his associate.

Messrs. W. P. Taylor and J. A. Vogleson were appointed as delegates to represent the Engineers' Club on the Committee which is studying the question of a federation of the local technical societies.

Messrs. J. H. M. Andrews and Charles F. Mebus were appointed as delegates to represent the Engineers' Club at the Annual Meeting of State College.

Regular Meeting, May 12, 1914

Present: President Swaab, Vice Presidents Mebus and Snook, Directors Haldeman, Furber, Yarnall, Hibbs, Wagner, the Secretary, and the Treasurer

The minutes of the meeting of April 16th were read and approved.

The resignation of Mr. Hess as a member of the Board of Governors was presented and accepted with regret.

Mr. H. A. Moore was then unanimously elected to fill the vacancy caused by the resignation of Mr. Hess, term to expire February, 1917, and the President appointed Mr. Moore on those Committees from which Mr. Hess resigned as a Director.

The following were elected to constitute the Committee on Nominations for the coming year:

Carl Hering, Richard Gilpin, Richard L. Humphrey, Thomas C. McBride, H. E. Ehlers, H. H. Quimby, R. G. Develin; Alternates, E. M. Evans, W. P. Dallett, George W. Hyde, George T. Gwilliam.

The resignation of Mr. Theodore W. Pinard was accepted.

The Membership Committee presented its report and the following were elected: To Junior Membership, Adam Cooper Warfel and Jordan Homer Stover; to Active Membership, Frederick Lennig.

The Treasurer reported a net gain to May 1st of $24.98, as compared to $1,790.19 for the same period of 1913.

The Treasurer was authorized to purchase a Universal adding machine for the Club office.

The report of the Committee on By-Laws was presented and accepted.

The questions of providing a booth for moving picture machine and the placing of awnings on the front of the house was referred to the House Committee, with power to act.

On motion, the following resolution was passed:

Resolved, That engineering and technical societies be allowed desk room in the Club house for secretarial purposes, free of charge, upon application, which application shall be approved by the Board.

Mr. Snook was appointed a Committee of one to devise ways and means for increasing the membership of the Club.

ABSTRACT OF MINUTES OF THE CLUB

STATED MEETING, APRIL 4, 1914

The meeting was called to order by Vice President Mebus with 97 members and visitors in attendance. The minutes of the Regular Meeting of March 21st and the Special Meeting of March 14th were approved as printed in abstract.

The Secretary announced that Colonel George W. Goethals and Mr. Benjamin Smith Lyman had been unanimously elected to honorary membership.

Mr. Edwin S. Jarrett presented a paper entitled "The Foundations of the Woolworth Building."

Mr. G. F. Shaffer presented a paper entitled "The Difficulties Encountered in the Construction of the Woolworth Building."

The papers were discussed by Messrs. Manton E. Hibbs, W. C. Furber, D. Robert Yarnall, and Edwin S. Jarrett.

REGULAR MEETING, APRIL 18, 1914

The meeting was called to order by President Swaab with 103 members and visitors in attendance. The Secretary announced that the Board of Governors at their meeting, held Friday, April 17th, had elected to membership the following: Active, Harry Bortin, Fred W. Fernald, Frederic M. Gardiner; Associate, O. C. Gilbert, Wm. R. McLain.

The death of Alexander E. Harvey, Jr., active member, was also announced.

The papers of the evening were presented by Mr. E. P. Roberts, of Cleveland, Ohio, and Mr. Charles G. Darrach, of Philadelphia, entitled, "Report on Public Service Properties," and "Valuation of Properties of Public Service Corporations," respectively, which were discussed by Messrs. Ledoux and Parker.

JOINT MEETING OF ENGINEERS' CLUB AND THE AMERICAN SOCIETY OF MARINE DRAFTSMEN, DELAWARE RIVER BRANCH, MAY 2, 1914

The meeting was called to order by President Swaab at 8:35 P. M. with 146 members and visitors in attendance.

Mr. W. A. Dobson, naval architect, Wm. Cramp & Sons Ship and Engine Building Company, presented the paper of the evening, entitled, "The Evolution of the Modern Battleship," which was discussed by Messrs. Hess, Hentz, Parker, and S. H. Wright. Mr. Elliott Snow, naval constructor, Philadelphia Navy Yard, and Mr. A. L. Church, of Baldwin Locomotive Works, also spoke on the subject.

A unanimous vote of thanks was extended Mr. Dobson.

REGULAR MEETING, MAY 16, 1914

Secretary announced that the Board of Governors at their regular meeting held May 12, 1914, had elected Adam Cooper Warfel and Jordan Homer Stover to Junior Membership.

The names of Dr. Carl Hering, Richard Gilpin, R. G. Develin, Richard L. Humphrey, Thomas C. McBride, E. M. Evans, W. P. Dallett were submitted to the Club as having been elected by the Board of Governors to constitute the Committee on Nominations for the year, in accordance with Article V, Section 2, of the By-Laws. The list was ordered printed and brought before the Club at the June meeting, at which time it will be altered or accepted.

Joseph W. Richards, Professor of Metallurgical Engineering, Lehigh University, presented the paper of the evening entitled "Electrometallurgy," which was discussed by Messrs. Hering, Hess, H. M. Chance, Kenney, Thomas M. Chance, Maignen, Goodwin.

Mr. Hutchinson moved a vote of thanks which was amended by Mr. Hess, to include the commiseration of those present to those members who could not get to listen to Prof. Richards' splendid paper.

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PROCEEDINGS

OF

THE ENGINEERS' CLUB

OF PHILADELPHIA.

ORGANIZED DECEMBER 17, 1877. INCORPORATED JUNE 9, 1892.

NOTE—The Club, as a body, is not responsible for the statements and opinions advanced in its publications.

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PAPER No. 1142

THE EVOLUTION OF THE BATTLESHIP OF THE DREADNAUGHT TYPE

By W. A. DOBSON

May 2, 1914

The ship of the line, built of wood, reached its greatest development just prior to the Civil War of the United States of America. The change from wood to iron covered a period of twenty (20) years, or from 1856 to 1876. A little later than the end of this period sail power was abandoned and steam relied upon entirely, the last full rigged ship of the United States Navy being the "Newark" as originally built. In wooden vessels the United States led the way among the nations, and its models and methods of construction were eagerly sought after and copied by foreign navies.

The "Hartford" and "Franklin" classes were of the best American type, and were immediately followed in the English Navy by similar vessels. The United States was rich in building materials, especially in live oak, from which the frames of the vessels were made, and which was practically indestructible. For this reason, perhaps, as well as that its corps of naval constructors were men of great practical skill in wooden ship building, the United States continued the use of wood when the lack of such material

was driving the European navies into the use of iron in place of wood.

A study of the construction of one of these fine specimens of naval construction is of great interest, especially when the construction was more or less composite. In the best vessels iron was used in strapping the frames both inside and out, and reinforcing the upper strength members, with iron clamps. The vessels were full rigged, having auxiliary machinery capable of steaming at 10-knots' speed. They were fitted with two-bladed propeller wheels, which were hoisted or triced up above the water line when the vessels were under sails.

The vessels were armed with smooth bore muzzle loading guns. generally of 8-inch diameter of bore, throwing solid shot of 68 pounds and having a penetration of about four inches in wrought iron at close range. Later in the United States Navy eleven-inch pivot guns were used, one being mounted on the centerline, usually forward, and served on either broadside.

The reason for the superiority of the United States designs for wooden vessels of this period is perhaps little understood at the present day. To fully appreciate it one must have intimate knowledge of the character and personality of the corps of constructors of the Navy at this time. For many years the design of vessels rested in a Board of Navy Commission, to which were attached a Chief Naval Constructor and a Chief Engineer. Later both Branches were detached from the active control of the Line and became separate Bureaus. At the head of the Construction Bureau stood Mr. John Lenthall, a man educated in the French technical schools of the time, which were certainly ahead of the world in mathematical investigation of the principles of applied mechanics, especially in the field of Naval Architecture. Mr. Lenthall was the peer of any naval architect of his time in technical ability and training, either at home or abroad, and to him alone must be given the credit for the strength of construction and harmoniousness of design that characterized the vessels of the United States Navy at this period. The remaining members of the corps under him were men of great practical skill in shipbuilding and of great natural ability, though perhaps with little knowledge of the application of mathematical principles to the art of shipbuilding.

With Mr. Lenthall to advise as to the disposition and combination of materials, for the use of iron was adopted for increasing the

strength of the members under greatest stress, and a score of men like William Hanscom, Mintonye, and the Harts to carry into execution his ideas, the United States had the finest wooden vessels afloat, by right of technical and practical skill, which we are little apt, in these days of more widely diffused knowledge, to be willing to accord to these giants of their day.

Unfortunately Mr. Lenthall did not believe in the Monitor type and refused to commit the Bureau to the advocacy of their construction. The "Monitor ring" was strong both in politics and in the Gustavus Fox wing of the Navy Administration, consequently the design and construction of the Monitors prior to 1875 were taken out of the hands of the Bureau of Construction and Repair and placed in the hands of the Engineers of the Navy, with Mr. Stimers at their head. The result of the study and design of the Engineer Board was the class of Monitors known as the light draft Monitors which owing to miscalculation would not float and proved a complete failure. As a "cub" in the Roach shipyard, I was much interested in seeing several of these broken up and noting the skill displayed in their construction. After this fiasco the design of the Monitors "Puritan" and "Miantonomoh" class were placed in the Bureau of Construction and Repair under Mr. Isaiah Hanscom, who succeeded Mr. Lenthall as Chief of Bureau.

The scarcity of building material led to the building of iron vessels in the English and French Navies. The idea of an armored vessel seems to have occurred to both these nations at about the outbreak of the Civil War with us and the result was the "Warrior" in England and the "La Gloire" in the French Navy. The belt of armor on each vessel was made four inches in thickness, which was sufficient to repel the 8-inch smooth bores of the day at fighting range. It should be borne in mind that vessels carried as many as fifty of the 8-inch 68-pounders arranged in broadside with bow and stern chasers. While this development was going on abroad some of the brightest minds, quickened by the possibility of war in the United States, were giving earnest thought and study to a fighting machine, notably John Stevens and Theodore Timby, American born citizens, and John Ericsson, a Swede, who afterwards became an American citizen. Stevens made the plans of a remarkable vessel called the Stevens Battery and at his death left a sufficient sum of money available for the completion of the

vessel. The vessel, however, was never completed, but some of the features of her design will be referred to later on. Theodore Timby had given years to the perfection of a revolving fort or turret of steel, in which was housed a number of guns. This fort he mounted on a raft which was intended for harbor defense. I have talked with Mr. Timby, and have gone over with him the original plans made in the '50's, and am glad to bear testimony to the originality of his design. It remained, however, for the genius of Mr. Ericsson to combine the ideas of both Timby and Stevens in the epoch making vessel known as the "Monitor." I fully believe Mr. Ericsson was working along entirely independent lines from either of these gentlemen, but all three had many ideas in common, and the fact remains that Mr. Timby was so protected by patents of his design that Mr. Ericsson had to pay $5000 royalty on each of the turrets fitted on the Monitor class.

Just here we will refer to the Stevens battery, which has a lasting influence upon subsequent warship design. Its building period extended over such a term of years, from 1860 to 1870, that many of its original features were modified entirely and the experience of the naval combats of the Civil War incorporated. However, Mr. Stevens started out to build an armored vessel with guns of one calibre carried in revolving turrets. In this general conception he and Ericsson were on common ground, but Stevens went much further. He introduced the armored deck with sloping sides extending down to the lower edge of the armor belt, precisely what was known as the protective deck of later years. His main belt extended from stem to stern. The vessel was fitted with twin screws, and the same type of balanced rudder now fitted to nearly all United States battleships found its prototype in this wonderful vessel.

Unfortunately the vessel passed into the ownership of the State of New Jersey and was never fully completed. Attention, however, is called to the features incorporated and actually built which afterward became fundamental in battleship design:

1. Battery of one-calibre guns mounted in turrets.
2. Twin screws.
3. Protective deck.
4. Balanced rudders fitted in the deadwood or run of the vessel.

While these features were being dreamed upon and slowly put into execution, Mr. Ericsson, for the Northern States, and the designer

of the reconstructed "Merrimac" were pushing ahead and forcing upon their governments types of vessels that were to revolutionize the design of war vessels the world over, and which were known as the "Monitor" and "Merrimac." In the former was the complete waterline belt and armored deck with guns mounted in turrets, while in the "Merrimac" was found the armored casemate with sloping sides and the ram. The combination of these features has been perpetuated in battleship design to the present day.

The United States Government was so exhausted financially by the long war that it had neither means nor inclination to carry into effect the many lessons of the war, but England, ever watchful, profited to the utmost by the experience gained in our naval engagements and embodied them in the navy of iron vessels she was rapidly building.

About this time there arose in England a group of notable men who by practical and technical training were well able to establish and apply the valuable lessons of the American Civil War. These were Scott Russell, Brunel, Sir Edwin Reed, and Rankine, followed by William John, William White, Nathaniel Barnaby, Francis Elgar, and Martel, while in France such men as DeBusy and Bertin were investigating and working along the same line.

To Russell must be accorded the credit of starting scientific inquiry into the lines of the least resistance, to Brunel the best disposition of material to meet longitudinal stresses, and to Reed and his young assistants the cellular construction and framing which did so much to obtain the necessary strength with less weight.

The designs evolved ran the gamut of the armored broadside with multiple guns of the "Warrior" type to the battery of few guns of larger calibre mounted in turrets, such as the "Devastation" type of high freeboard Monitors. These designs finally worked into the mixed gun battery with the large guns mounted in turrets or barbettes and the smaller guns in armored casemates. This type of battery prevailed in one form or the other, up to the time of the Russo-Japanese War. The fight through that long period was between armor and guns, with varying results. At one time the armor would defeat the guns, then the guns would penetrate the best armor made. The same fight is still on, with honors resting with the guns. Then began the long fought question between speed and protection and armament, or the feature of offense and defense.

The lesson hastily drawn from the fight in the Japan Sea was the all gun battery of heavy guns, with a numerous secondary battery of very small guns. Calm and cooler consideration, however, has given the larger calibre rapid firing gun its old place as a defense against torpedo craft, with the exception perhaps that protection for this class of gun has been dropped. The cycle has been made and we are again with batteries of mixed calibres just as at the close of the Civil War, only with all the tremendous increase in power and rapidity of fire.

At the time of the Spanish-American War our battleships had as their primary batteries 13-inch or 12-inch guns, combined with 8-inch, all in turrets, the heavier guns being mounted on the centre-line forward and aft, and the 8-inch on either beam. The secondary battery ranged from 6-inch down to 3-pounder rapid fire guns. The chief lessons taught by this war, insofar as battleships are concerned, were the value of keeping a navy in the pink of condition, both men and material; the necessity of radical changes in our own target practice; and the necessity of adopting smokeless powder. The gallant effort of Cervera's fleet, without proper stores or good ammunition, and its pathetic destruction, as compared with the famous trip of the "Oregon," speaks volumes for the necessity of a high standard of naval efficiency and drill. The remarkably low number of hits for the number of shots fired was a surprise to our naval authorities and brought about such a radical reform in target practice, mounting of guns, and service of ammunition, that today our vessels are excelled by none in the number of target hits.

For the purpose of our discussion, the features of the modern "Dreadnaught" may be considered under two heads: viz., Offense and Defense.

There is a certain amount of displacement at the disposal of the designer, for the sum of all the weights must equal the displacement at a given line of flotation. Therefore, no one feature can be abnormally emphasized except at the expense of some other; for instance, to carry a great number of heavy guns and ammunition means thinning down the protection in shape of armor. The vessel may be strong in offense but correspondingly weak in defense. The speed may be made extremely high, and combined with heavy armament will produce a vessel that can deliver a blow and run, but she cannot take punishment, for she must lack commensurate

protection. It seems, therefore, that the wiser policy is one of good speed and equally balanced armament and protection. These are the general features followed for American Dreadnaughts. The amount of weight devoted to the comfort and health of the ship's complement can well be considered as belonging equally to offense and defense, for the sound mind and the sound body are pre-eminently necessary for the successful issue of the battle.

The features of offense may be grouped under three heads: 1st, the battery of primary or heavy guns; 2d, the torpedo battery; and 3d, speed, when considered as a means of overtaking an enemy and choosing the weather gauge at the time of engaging.

The features of defense may likewise be grouped under three heads: 1st, armored protection; 2d, the auxiliary battery, as a means of repelling torpedo boat attack; and 3d, speed, as a means of refusing an engagement only.

The two divisions are so closely interwoven as to make it hard to consider them apart except in general terms. We may, therefore, take up the features in a general way and afterwards combine them.

First comes the main feature of offense, i. e., the primary battery. Almost all nations have come to the one-gun battery for its chief weapon of offense. These guns range from twelve inches to fourteen inches in diameter of bore, with the prospect of going as high as fifteen inches. The weight of armor piercing shell and the bursting charge vary in general terms as the cube of the diameter of the bore of the gun. It will be seen, therefore, that the impact from a 15-inch shell is practically double that from a 12-inch shell.

The emplacement of the heavy guns, therefore, is one of the first importance, for the gun must be so placed as to command the greatest arc of fire at such a distance from the water as to be fought in moderately heavy weather, and so placed that its protection by heavy armor is feasible. This opens the question as to whether head and stern fire or broadside is the more valuable. Some designers sacrifice weight for the supposed advantage of head and stern fire. In coming up with and engaging an enemy no doubt head and stern fire will be valuable in the hope of getting in a crippling shot at very long range, but when the vessels are within good fighting distance it is most natural to suppose that the pursued will sheer enough to bring the greater number of guns, or her broadside, to bear on the pursuer, who will also adopt like tactics so that the fight will continue, the vessels circling in parallel lines.

In fleet action the use of the battery in broadside is the one giving the greatest delivery of metal. It, therefore, seems that the greater advantage is to be gained from a moderate degree of head and stern fire combined with the heaviest possible broadside fire. To obtain this with the least weight of protection we are irresistibly led to placing the guns on the centre line so that they may fire on either broadside. To have the advantage of this system and at the same time obtain good head and stern fire the United States designers were forced to place the second set of turret guns from the forward and after ends, so that they could fire over the guns in front of them. This emplacement was brought out in the "South Carolina" class and strongly criticised at first, especially by England, who feared the effect of the blast from the upper guns upon the crew of the lower turret. Exhaustive experiments in this line have proven that the fear is groundless, with the result that this emplacement has become the standard of all nations.

In the early American Dreadnaughts the heavy guns were mounted in pairs in turrets, using the standard American emplacement. This arrangement gave at the best four guns ahead and astern, with the broadside varying in accordance with the number of turrets mounted. This has given place to mounting three, and in the French Navy even four, heavy guns in a single turret. With a battery of ten or twelve heavy guns the emplacement may be made in four turrets, the forward guns and their ammunition being entirely clear of and forward of the machinery, while the after guns and ammunition abaft the machinery. This is a most desirable arrangement, as it lends itself to the better ventilation of magazines and prevents interruption between engine and fire rooms. In one case we may have three guns each in the lower turrets and two each in the upper firing over the turrets below. This would give five heavy guns ahead and astern and ten on either side. By using three guns in each turret the head and stern fire may be increased to six guns and the broadside to twelve. The French in their latest design have placed four guns in one turret. With twelve guns, if mounted in four turrets, this would mean no increase in head fire over the 3-gun turret, but renders it possible to mount all twelve guns in three turrets, with the second turret firing over the first, giving eight guns ahead, twelve on broadside, and four astern. All sorts of variants may be made by using the

several types of turrets here spoken of. Personally, I do not believe the four-gun turret will prove successful. The outboard pair of guns must be placed so far from the center that in firing a single pair the whip must be enormous. Of course, in firing in salvo this objection is not a serious one. However, the number of guns per turret may vary. The mounting of all heavy guns in turrets protected by armor and placing these upon the centre line has been universally adopted and the United States must be given the credit for originating this plan, embodying the greatest efficiency with the least weight.

The next feature of offense is the torpedo battery. The use of torpedoes on battleships is almost universally confined to submerged tubes. As these are placed generally in broadside below the waterline they are from their location well protected. There seems to be little actual experience from which we may measure the value of this arm of offense. The range has been greatly increased, and from the fact of their power to damage a vessel so much greater than the gun they must have serious consideration. They are used at comparatively close range and, therefore, must necessarily be the weapon to aid in giving the finishing touch to the conflict. A vessel may be fought after she has been hit by many projectiles from the main battery, but she cannot survive many hits from modern torpedoes.

These weapons deliver their blows below the armor belt and at the most vulnerable part of the ship, so that one explosion from a successful delivery may seriously cripple the battleship, and more than one may put the ship out of action. The old "Maine" in Havana harbor is an example of the destructive effect of an underwater explosion.

Speed is next to be considered as a means of offense. It can well be conceived that under certain circumstances speed is a most valuable adjunct to the offensive power of a battleship. It means arriving speedily at the scene of action, the overtaking of an enemy, and the choice of the weather gauge, all valuable assets for the battleship, but where we emphasize speed in excess of 21 knots at the expense of the armament and protection of the vessel we are departing from the true battleship. It is possible to conceive a cruising battleship with such heavy guns lightly protected, and such tremendous speed that she can keep out of range of the slower vessel with more protection and less calibre of guns, and deliver

her blows with impunity. This may look well on paper, but it is entirely possible to arm the slower vessel with the largest calibre guns. Then the usefulness of the swifter but lightly protected vessel as a first class battleship ceases. I fully believe the United States is right in adopting a speed of about 21 knots and putting the difference of weight into protection. It seems to me to be a fallacy that the most efficient protection that can be given to a ship is the protection furnished by its own powers of offense. This has been ably argued by some of the leading experts, especially in England, but the answer seems to be found in a fewer number of equal calibre guns, but so well protected as to be able to reply with full vigor to the first onslaught of the vessel with a greater number of guns with little or no protection. It is the expectation of artillery experts that with the present accuracy of gun fire and firing "in salvo," an engagement between battleships will be settled in less than ten minutes. The staying power then is to be found in armored protection to the primary battery and vital parts of the vessel. If this theory is well founded, the engagement will be over before a ship's torpedoes can be brought into action, and the value of torpedo craft during an action of such short duration very much lessened.

This brings us to the features of defense. It is obvious that to have a perfect fighting machine we must be able to protect our motive power, our ammunition and supply of same, our guns, and the stability of the vessel. In other words, the armored portions must be sufficient in area and thickness to have our vessel a floating fort capable of fighting its guns and of being maneuvered at will, even after the habitable portion has been swept away or laid open to the sea by gun fire. This means a careful consideration of the moment of inertia of the plane of flotation included within the armored area, and which may be considered as remaining intact after the most severe fighting.

Taking then a four-turret battleship carrying ten to twelve 15-inch guns as its primary battery, and having sufficient power to give a speed of 21 knots, it would seem that the main armor belt should extend to and include the foremost and aftermost barbettes protecting our turret gear and ammunition supply, and should be at least fifteen feet in depth. Forward and abaft these points the armor should extend to the bow and stern in the form of a water-line belt. At the top of the main belt should be worked the main

protective deck carried flat across the vessel; below, at a height of about three feet above the load line, should be worked a splinter deck turning down at the sides to meet the armor shelf. The slopes of this deck should be of considerable thickness to take care of shell fragments.

It may be of interest to dwell for a few moments on the development and application of the turtle back or protective deck to war vessels. As mentioned earlier in the paper, the Stevens Battery incorporated this feature, but before this a lieutenant in the U. S. Navy, by the name of Hunter, invented an armored deck with the sides sloping down at the sides of the vessel below the waterline. In the development of foreign war vessels this system was adopted for the protection of the magazines and machinery of protected cruisers and in some cases sole reliance for protection to the vital portion of the vessel was placed in decks of this sort for ships of large displacement and heavy artillery. Later on, this principle was applied to battleships, the idea being that if the projectile penetrated the belt armor the armored deck would stop the fragments of shell or deflect the solid shot.

The accepted method of the present day is to work a flat deck of armor at the top of the main deck and a sloping deck not more than one and one-half inches thick on the slopes as a splinter deck.

It has been proposed to work the main belt in two thicknesses having a space between filled with wood, the outer thickness to be two or three inches and the remainder of belt in one thickness; the object is for the outer belt to receive the first shock of capped shell and the second or main thickness to deflect the shell which would be decapped by the outer armor. The barbettes and conning towers would begin at the main armored deck and be carried as high as the design would require. We would then have an armored raft with forts formed by the turrets and barbettes, the armor absolutely protecting machinery, magazines, ammunition supply, steering gear, guns, commander's position and means of interior communication, and the stability of the vessel. The rest of the vessel could be shot away and yet the fighting machine be intact. We are, however, still in danger from torpedo attack. To guard against this, internal armor is fitted abreast magazines and machinery corresponding about to the limits forward aft of the deep belt of external armor, extending from the inner bottom to the splinter deck. The space between the armor and the outside

plating (which should be as great as practicable) is divided in cellular compartments. From attack by torpedo boats our defense lies in the auxiliary battery of rapid fire guns of sufficient size to sink the small craft. These gun positions should be unarmored, that is, not protected by armor, for armor commensurate with the size of guns would be smashed into fragments by the heavy guns of the enemy's primary battery and become a distinct source of danger from the mitraille. It therefore seems useless to expend good displacement in this manner. If the theory of the artillerists is a sound one, that the battle will be over in less than ten minutes, torpedo boat attack during an engagement is impracticable and should be made preceding a battle. If, however, as many hold, the battle is to occupy considerable time, it would appear that the psychological moment for torpedo boat attack would be after the battle had been under way for some time and the auxiliary battery put out of commission. Speed as a means of defense seems to be solely in the ability of the vessel to keep out of danger by refusing to engage, but this would be against all traditions and avoiding the very purpose of the battleship.

The location of magazines at their best is forward and abaft the machinery spaces. There the magazines can more readily be kept cool and the stowage of ammunition not interfere with the arrangement of the boiler and engines. The powder used, nitrocellulose, in our guns deteriorates very rapidly when heated above 90° F. It therefore becomes necessary to ensure the stability of the powder and to prevent the generation of dangerous gases caused by the decomposition of the powder by means of cooling the magazines artificially and so keeping the temperature down to a point of safety. To accomplish this the magazines are lined on the inside with compressed sheet cork varying from two to four inches in thickness. This is cemented directly to the steel plating, frames. and beams of the steel structure. After the cork is in place the seams and joints are smoothed up with plastic cement and then the whole surface coated with plastic cement until a smooth surface is obtained. This surface is in turn painted with gloss paint, the object being to obtain a polished surface which will be slow in radiating heat. The rougher the surface the greater the radiation of heat, for each points acts as a radiating fin. The smooth gloss paint gives as near as may be a uniform surface with slow radiation. The magazine having been insulated in this manner, a series of

supply and exhaust ducts are fitted, reaching to all parts of the magazine. The air drawn in the first place from the atmosphere is forced through an air cooler and moisture separator. By closing the intake from the atmosphere the air is circulated to the magazines and back through the cooler until the desired temperature is reached. The admission of air to the magazines is controlled by thermostats and dampers, which enable us to keep a uniform temperature in the magazines.

The present day battleship resembles a miniature city in its provision for the safety and health and comfort of its officers and crew, to which must be added all the apparatus for sending this mass through the water at a speed of 21 knots, or nearly 25 miles, an hour, and handling the vast engines of destruction lying latent in its magazines and enormous guns.

Let us look at these. First, we must have light throughout the vessel, so an electric plant for lighting must be provided and wiring to conduct the current to all parts of the vessel. Drinking water must be provided, so an evaporating plant is fitted to enable the salt water to be turned into good potable water. This is conducted to the various bath rooms, lavatories, and drinking scuttles throughout the vessel.

Heat must be provided and means arranged whereby fresh air, heated by steam, is forced into and through the living quarters.

The turrets and guns must be so mounted that each set may be trained at will, or elevated and depressed, as one man may elect. Reliable apparatus for this purpose must be provided. The ammunition must be brought from the magazines down below the waterline to the breeches of the great guns in the turrets some fifty feet above; each shell may weigh three-quarters of a ton and must be brought precisely to the loading position at the rear of the gun. Then a rammer must reach forth its long jack-knife like arm and push the shell and then the powder home in the chamber of the gun. This must be done in any position of the gun, so that electric mechanism reliable and flexible to a degree must be provided.

The vessel must have apparatus for mooring and docking, so winches driven by electricity supply this want.

Outside of a navy yard, when a war vessel is in commission, she is rarely tied up at a dock, so that small motor and rowboats are a necessity for communication with the shore. These boats must be stowed out of the blast of the guns, for, although in a

battle the boats are lowered and moored in the open sea, yet in peace time the boats must be so stowed that the guns can be fired at target practice without tearing them to pieces by the blast. This necessitates nesting them and handling them by cranes or derricks operated by electric winches.

A gear for the rapid coaling of the battleship must also be installed, which finds its best motive power in electricity. The most modern, approved type of steering the vessel is by mechanism actuated by electricity, for this action is positive and reliable, and such an apparatus eliminates steam pipes with their heat and leaks in the living quarters and storerooms.

In addition, the ice machinery, laundry equipment, galley, and baking apparatus are operated by electric motors, so that the battleship must be provided with no inconsiderable electric power plant.

As referred to earlier, the magazines must be artificially cooled, the perishable stores for the food supply of some 1200 men must be kept in cold storage, and ice for ship's use must be made. To accomplish this an ice plant is provided. Up to the present time the type of ice machine used is the "dense air," in which the air is alternatively compressed and cooled, then expanded.

A sewerage system must also be arranged for, as we have on a Dreadnaught as many people as are found in many villages of the first class. Consequently, drains from baths, toilets, washrooms, galleys, and decks all have to be provided.

The battleship is no exception to the general dictum that "bread is the staff of life." Therefore, means for supplying some 1200 men with good bread are ample and thorough. Bakeries are fitted, provided with power operated dough mixers, and with dough testing apparatus. In addition, all utensils for cake and pastry baking are provided.

Next comes the laundry, for the clothes of the sailors are washed and ironed by machinery; so all the appliances, both steam and electric, found in a first-class laundry have their counterpart on a battleship.

Then the sick must be cared for, ordinary cases of illness separated from contagious diseases and from those where the knife is the sole resort. We have then the ordinary hospital or sick bay with its contagious ward, and an operating room furnished with all the antiseptic appliances and instruments which make successful operations of the most serious character.

Next comes attention to the moral and spiritual side of the natures of the men. It is human to err, and the crew of a Dreadnaught are intensely human; hence, a jail on shipboard with several cells, where a diet of bread and water tends to good resolutions. But all men are not bad and bad men are not always in trouble, so there is a chaplain on board who at stated periods conducts divine service and to this end must be provided with a pulpit, and this makes the church.

So each battleship is a fortified city, carrying within its armored walls all the activities of the ordinary citizen, but always with the refining and civilizing influence of women absent, and we have nearly all the ordinary municipal plants in operation, for we have light, heat, water, drainage, power, hospitals, church, and laundry plants quite as in a well ordered city.

In the evolution of the battleship, one element of doubt pertaining to its design has been removed, and can now be determined before hand with absolute and scientific accuracy. I refer to the powering of the vessel.

In the days when fourteen knots was considered a high speed the power necessary to drive the vessel at a speed not exceeding fourteen knots was ascertained largely by the use of Rankine's formula, which took into account the wetted surface of the vessel, the entering angles of the vessel's form and the water set in motion by the passage of the vessel through the water, or what he termed augmented surface.

When higher speeds came more and more into vogue it was seen with regret that Rankine's formula had its limitations and something more reliable than an "educated guess" must be substituted. About this time Mr. Froude began his resistance investigations on behalf of the English Admiralty, which became world famous and led to the promulgation of the method of comparison known as Froude's Law of Comparisons. This was a great boon to the designer, where it was impossible to have the resistance of the model ascertained by tank experiments, provided that one had a sufficient stock of trial data for vessels somewhat similar in form. This was the method used by the Navy Department prior to the installation of the model basin apparatus at the Washington Navy Yard, under the auspices of the Bureau of Construction and Repair. In those days it was customary for the Bureau of Steam Engineering and the Bureau of Construction and Repair to prepare independent

curves showing the power required at various speeds and then compare them. A reasonable margin was added to the power for safety's sake, and then in designing the machinery a little margin was allowed to be sure that the prescribed power would be obtained. From this it can be seen that it was not so difficult a matter to obtain a very considerable premium for speed in excess of the contract requirements, when such bonuses were allowed. With the coming of more exact methods, instituted by that very able constructor of the United States Navy, Mr. David W. Taylor, the bonus system was swept away and the contract made for a definite speed; anything obtained above it was simply glory for the contractor.

Ascertaining the resistance of the model for a certain range of speeds not only causes one to await quietly, without undue loss of sleep, the outcome of the speed trials, but makes it easier to place the cause of the trouble, if any is experiences, where it properly belongs.

In the old days, when the vessel failed to realize her expected speed the engineer at once laid full blame upon the form of the hull, a trick not yet entirely forgotten by our brothers on the engineering side of the fence. Now that the hull resistance can be definitely foretold, and the engines found to be capable of developing the required power, inquiry turns at once to the design of the propeller wheel as the unknown factor, and one where experiment may give beneficial results. In other words, it narrows investigation down to one element instead of any one of three. There is still further benefit to be derived from model tank results in warship design, where every ton of displacement is of great value. In general terms, increase in power means increase of weight, and when a generous allowance has been made to insure the necessary power being obtained it must be at the expense of weight; in other words, some other department of the vessel is being robbed of its proper share of the given displacement in order that we may be sure of our speed. The model tank prevents this by showing us the necessary effective horsepower at the very start of the design. This also follows into the radius of action for a vessel. The necessary fuel for a given radius may be accurately ascertained and unnecessary weight saved to go into armament or protection. The design and development of Dreadnaught battleships present as many features of interest today as war. The gun is

undefeated by armor, and the submarine has had no adequate reply made to the possibilities of its attack. A feature that must be given serious consideration is protection against an attack from the sky. This may well take some form of turtle back in connection with the upper level of protective deck plating.

DISCUSSION

CHAIRMAN.—This paper is so able that there is, I suppose, nothing left for discussion, but there may be some questions that somebody will want to ask Mr. Dobson, and probably he will be willing to answer them.

MR. HENRY HESS.—I remember a number of years ago, when I was connected with the Ordnance Department of the Army, we were much interested in the accuracy of gun fire, and the only experience we had at that time with relatively recent ordnance was somewhere down in South American waters, where I believe the various battleships had records of rather marvelous accuracy, but nothing like 99.9% pure as we have today. I believe the observed accuracy on those vessels was something under 2% when the other fellow was shooting back; it may possibly have been 3%. They claim an efficiency today, for shooting at a target, of, I believe, somewhere around 90%, and some say 100. It would be interesting to know what the accuracy of fire is going to be when the other fellow shoots back.

MR. SNOW.—Permit me to say that this is a very splendid paper from Mr. Dobson on the Evolution of the Battleship and Warship Design, and the more I think of it the more I have forced upon me the truth of the expression used by Mr. George W. Dickey of the Union Iron Works, San Francisco, that "the modern battleship is a complicated combination of compromises."

The paper being to some extent historical, may I be allowed, to add one item that is now somewhat historical, but nevertheless an important question even at the present time? I allude to the use of cofferdams. These were first seen in the French Navy, and were first used on the Cruiser "Sfax." At the time we students were in Paris, we received a request for information as to the kind and character of material used to pack the cofferdams. Curiously enough, about the same time that we got this request there appeared in the Paris edition of the New York Herald a reference to the same subject, on the effect of cofferdams on ships, and also, by a curious coincidence, on that same day a French Officer, high in authority, made a social call on us youngsters. We promptly turned the conversation toward the question of cofferdams and got the information that we wanted, namely that "coco" cellulose was being used as a packing material.

MR. A. L. CHURCH.—The question of the weight that goes into a battleship is a vital one, and it may be interesting to some of you to know that an Admiral when he is put aboard ship weighs about 75 tons; you have to provide for the Admiral, the band, his crew, and sometimes an extra aide, etc.

Another question deals with the accuracy of fire, and particularly on going around to a point of range at top speed, and this is the danger zone in firing, with our modern twelve-inch and fourteen-inch guns and large projectiles; the

danger is greater in the fore and aft directions, and it is in the broadside direction that I think you will find every commander will try to fight his ship.

Re-arranging of the magazines was discussed, and placing them where they could be cooled; this is done by means of cooled air, or by allowing a jet of air to extend into the magazine, and I think the latter method is generally in favor.

Again as to accuracy of fire, I think the advantage lies with the one who shoots first, because after the first shot the other fellow will have no chance at all. The point is to get at the enemy first. The destructive effect is so great that, unless your opponent has also exercised at long distance firing, the man who gets in the first few broadsides will probably put the other fellow out of business.

I would like to ask Mr. Dobson what sort of protection has been afforded by attack from aeroplanes?

Mr. Dobson.—I think no protection in particular has so far been provided; there has been talk of constructing a turtle back deck over the vessel as a protection, but I do not think anything has been worked out as yet.

Chairman.—Has the gun been worked out that can reach the aeroplane?

Mr. Dobson.—Yes, the Department has developed vertical firing guns.

Mr. Hentz.—I would like to ask about the exact status of the submarine both as to coast defence and as to fighting on the high seas.

Mr. Dobson.—That is a pretty broad question, and I do not think I can answer it. The submarine certainly has great moral possibilities; it will keep a fleet from anchoring near a seaport within the radius of the submarine, but just what submarines will do in battle I am unable to say, although great things are expected of them. The submarine is a most valuable arm of the service, but I do not know of actual results obtained by any power that may be used as comparative data.

Mr. Wright.—I would like to ask something about the history of the military mast. We had a military mast on the Charleston that was lost some years ago.

Mr. Dobson.—All navies have a system of fire control located on military masts. The cage mast used in this country is distinctly an American design. The cage mast is built of tubes and is one that cannot be shot away as readily as the mast supported by the tripod system, or the single mast. The United States gunboats "Wilmington" and "Helena," built for Chinese waters, were provided with military masts. Some Japs came along at the time of their design and told the Department authorities to place the fighting tops high enough up to shoot over the banks of the river where the boats were lying. In this way the military masts of these vessels originated.

Mr. J. C. Trautwine, Jr.—I wish I were in position to discuss Mr. Dobson's paper.

Unfortunately I am handicapped, not only by dense ignorance of his subject, but by some maladjustment of my mental equipment, which forbids my taking the battleship seriously.

The battleship recalls the ancient story of the Chinaman whose house burned down, incidentally roasting the family pig, and who was thus led to the di[illegible]y

of the attractions of roast pig as an article of diet. The discovery led to the general burning of houses in China, for the sake of enjoying roast pig.

Presumably, the Chinese government organized a Department of Pig-roasting; private Chinese corporations devoted themselves, in all solemnity, to the skillful construction of houses adapted to the purpose; these houses may have been christened (or Confucianized) with bottles of the Chinese equivalent of champagne, and their engineers doubtless read papers upon the then modern developments in the design of such houses.

Now, my trouble is that, if I had lived then and there, I could not have resisted the temptation to wonder why my compatriots failed to see, close at hand and obvious to all, a vastly less inefficient method of procuring roast pig.

Similarly, today and here, each nation seeks its own interests, and yet each nation goes about serving its interest by means which can lead only to losses compared to which those of the house-burning Chinamen are insignificant.

And I am so constructed that, in spite of my interest in the technical features of Mr. Dobson's paper, this interest is overshadowed by the wonder that modern nations, presumably enlightened and therefore awake to their real interests, should (even in obedience to the traditions of antiquity) go on in a line of activity inevitably ruinous to those interests, while their own experience shows the overwhelming superiority of rational methods.

But these preposterous activities are still with us; and whatever is to be done should be done well. Mr. Dobson has admirably shown how our national folly is carried on today, and the Club is indebted to him for his masterly handling of the subject. I therefore move a vote of thanks to Mr. Dobson for his highly interesting (and, if possible, still more highly suggestive) paper.

PAPER NO. 1143

ELECTROMETALLURGY

By JOS. W. RICHARDS

May 16, 1914

I appreciate that you have come out a second night in succession, after your engineering meeting of last night. It is a pleasure to me to address you on a subject to which I have given a great deal of attention and which I want to make interesting to you. I wish to clear the ground first with a few advance remarks as to what electrometallurgy is.

One definition of metallurgy is: "The art of making money out of ores." The technical definition is: "The art of extracting metals out of ores and refining them to the purity required by every-day use." Metallurgy is a part of applied chemistry. Metallurgical operations are mostly chemical operations. Ores, with few exceptions, contain the metals as compounds and not in their native state. Therefore it is usually a matter of decomposing the compound, as easily and cheaply as it can be done, by means of chemical reagents. Electrometallurgy is the art of utilizing the electric current in obtaining metals from their ores, or in refining them for industrial purposes.

I have put on the board a table which sets forth the main divisions of elctrometallurgy. First, the electrolytic methods; and second, the electro-thermal.

I. Electrolytic Methods.
  1. Aqueous Solutions:
    A. Soluble anodes
      Electroplating: Au, Ag, Ni, Brass.
      Electro-refining: Cu, Pb, Ag, Au, Bi, Sb, Zn.
    B. Insoluble Anodes
      Extraction from Solution: Cu, Zn, Au, Ag.
      Cathodic Reduction: Pb.

2. Fused Salts: (Electrolytic Furnaces).
   A. Simple Salts: Na, Ca, Mg, Ce, Zn.
   B. Solutions in fused baths: Al.

II. Electro-thermal Methods (Electric furnaces).
   1. Fusion of metals or alloys: Steel, Brass, Bronze, Aluminium.
   2. Reduction of compounds to Metals or Alloys: B, Si, Mn, Zn, Ferro-Alloys, Pig Iron, Pig Steel.

Electric current can be utilized for electrolytically decomposing chemical compounds. The electro-thermal method is that in which the current is used for its heating power only, and in which some other agent does the decomposing. These two are very distinct from each other, and I will spend a few minutes in emphasizing the difference between them.

In the electrolytic method you depend upon the electrolytic decomposing power of the current. You necessarily have to use a direct current except where the electric cell itself rectifies the current, which is very exceptional. In all practical electrolytic operations, only direct current is used.

In electro-thermal work, where the current is used for its heating power only, direct current or alternating current may be used. Alternating current is cheaper and does not give the indirect effects that a direct current will give, for with direct current in an electric furnace you usually have undesired one-sided effects at the electrodes.

In the electrolytic furnace the amount of useful work done, as measured by the amount of the product, is proportional to the amperes of the current which pass, according to the laws discovered by Faraday. When you are passing a current through an electrolytic cell, the amount of product is independent of the volts which may be expended on the cell, and is dependent only upon the amperes. It is only secondarily that the volts used affect the amount of product which can be obtained by forcing through more amperes. It is easy to calculate the theoretical amount which you should get at 100 per cent. ampere efficiency upon the amperes flowing through any electrolytic cell.

In electro-thermal work the heat energy of the current is that which is utilized, and the heat effect is proportional to the amperes multiplied by the volts, so that the product will be proportional

to and determined by the amount of energy which is expended upon the furnace as measured by the K. W. H. meter. The two processes are thus seen to be essentially distinct in these two fundamental ways. A third distinction may also be drawn between them: that in the electrolytic apparatus you must have an anode and a cathode arranged for proper electrolysis, and proper arrangements for the escape of the gaseous products at the anode and the collecting of the products at the cathode. In the electro-thermal methods you have no such distinction of parts. There may be electrodes, or the terminals or poles, but they are not positive and negative, they are not anode and cathode, and there is no arrangement of the cell which copies or duplicates the electrolytic arrangement which is necessarily part of an electrolytic operation.

I will discuss now why the electrolysis of fused salts is sometimes classed erroneously under the electric furnace methods. Fused salts generally conduct current freely. Their order of resistivity is that of a well-conducting aqueous solution like the best conducting sulphuric acid, something like one to three ohms per centimeter cube. When you pass the current through and decompose fused salts, the operation is primarily electrolytic—the decomposition of affused salt to obtain its ingredients. However, you cannot pass an electric current through any solution or, in fact, through any material without generating some heat by the passage of the current. If you electrolyze with an intense current you generate much heat, and you may reach a point where the internal heat generated by the passage of the current is so large as to keep the electrolyte melted without the assistance of the external heat with which you started the operation. By running the operation with an intense current, it is possible to get the salt melted and keep it so without the aid of electrolysis, thus incidentally generating enough heat to keep the salt liquid at the temperature at which you run, 300, 400, or 1000° Centigrade, such as when producing aluminum, etc. And by regulating the current you can keep the temperature just at the desired point. Many writers have been muddled on this point, and have thought that when outside heat is dispensed with you then have a furnace, and they have classed these with electric furnace processes. That is taking them away from where they properly belong. The fact that the operation is essentially electrolytic is not affected by the fact that the heat generated partly suffices to keep the bath melted, and whether

the heat generated keeps the bath melted or whether you have even to cool it down, that does not affect the classification; it is not an electric furnace process. I would ask you, when you read about electrometallurgical processes, that you will bear that in mind that the electrolysis of fused salt, when the current supply is sufficient to keep it fused, is necessarily an electrolytic operation. Some people think that when you are conducting an operation requiring a higher temperature than the ordinary one, you necessarily have an electric furnace. This difficulty has been solved by using the term "electrolytic furnace" for an operation of this kind, where the electric current performs electrolysis and also supplies all the heat necessary to keep the salt melted.

Taking up now the different methods of electrometallurgy, starting with the use of aqueous solutions among the electrolytic methods, when the only source of electric current was the battery, the plating of silver, brass, etc., and other metals, by means of an aqueous solution and electric current, was the only branch developed. The Elkington Brothers in England were the best-known platers of gold, silver, and other metals, using aqueous solutions to do electroplating. According to my definition, electroplating with pure metal used as an anode would not be included in electrometallurgy, and I should say at the present time, that electroplating with a pure metallic anode is not an electrometallurgical operation in the strict sense. I mention this because in the early days, when the battery only was used as a source of current, electroplating was called electrometallurgy. In Mr. Shaw's first book, he assumes that electrometallurgy means nothing more than the plating of the metals, the duplicating of medals and coins, starting with a pure metal as anode, and simply changing its form and plating it over. From the old books up to the present you will find much in them about electroplating or, in general, galvanoplastics, the art of changing the form of a metal. Elkington Brothers, who were plating gold and silver, were the first to utilize this principle for refining copper, away back about 1865. When the first dynamo was invented—the first machine of Wilde—there arose the possibility of using impure copper as an anode and plating out pure copper, thus saving all the gold and silver contained in the impure copper. That was the first process by which it was possible to extract gold and silver from the metallic copper when they were present in very small amounts, and the process owed its commercial

success to treating cheap impure copper, saving the gold and silver, and at the same time obtaining a very pure copper at the cathode. This is a real electrometallurgical operation. It has a few fundamental principles which I will set forth as concisely as I can.

To electrolytically refine impure metal, you must choose as electrolyte a soluble salt in solution, such that the actual metal you desire to get will go into the solution, and then you must use a depositing current of such quality and quantity that you deposit only the desired metal out of solution. When you take impure copper as anode and thus electrolyze it, there remain undissolved, at the anode, the gold, the silver, the platinum, little specks of slag and matte, and particles of copper, which drop to the bottom. This anode mud will frequently be 50 per cent. copper and 30 or 40 per cent. silver and gold. The iron, nickel, zinc, cobalt, tin, and a number of other metals have gone into the solution. The current density at the cathode must be high enough to deposit the copper but low enough to let the impurities accumulate in the solution, whence they have to be removed by other means. Those principles are the foundation of the entire copper refining industry, by means of which about 900,000,000 pounds of copper per year are refined for use in this country, the value running over one hundred millions of dollars. Similar principles are used for refining lead. For instance, Dr. Keith, of Philadelphia, worked out a very satisfactory laboratory process for refining lead many years ago. It was not satisfactory commercially, however; but in later years the problem has been solved by Mr. Anson G. Betts, and there are two or three such plants in operation in this country and abroad giving us a lead of very high purity, free from silver and gold, and particularly free from bismuth, which is one of the most difficult elements to get out of lead by ordinary refining processes. Bismuth remains behind in the slimes in such shape that it can be purified, and this process has increased very greatly the output of bismuth in this country. The lead is so free from bismuth that it commands a high price, being particularly desirable in the manufacture of white lead, for a trace of bismuth in white lead spoils its color.

Another element which is being electrolytically refined is zinc, which is more difficult to refine than copper or lead. There is also less margin commercially than there is for refining copper, and there is no gold or silver in it whose saving pays for part of the operation, so the refining of it is not as profitable as that of copper.

The electrolytic refining of silver was first made practicable by Moebius.. Taking as anode the silver bullion which comes from the cupellation furnace, the silver, copper, and iron go into solution, while the gold and platinum remaining are not dissolved; by properly regulating the depositing current, only pure silver is deposited. Silver of the greatest commercial purity is made in this way.

Gold is electrolytically refined on the same general principles, but with differences in detail, by the Wohlwill process. The process was worked out at the Deutsche Gold und Silber scheide Anstalt in Hamburg. A solution of chloride of gold, electrolyzed with a sheet of gold as anode, gives off chlorine into the air, and the anode is not dissolved. If you add hydrochloric acid to that solution, making a strongly acid solution, there comes a point where the escape of chlorine gets less and less, until its escape is prevented altogether and the gold anode dissolves perfectly. That process was first put into operation in America at our Philadelphia Mint; I believe the electrolytic plant has since been moved to the assay office in New York. The gold, platinum, and copper go into solution, while the silver forms chloride and remains undissolved. By using a proper depositing current, pure gold is obtained. The gold beaters say they are getting much better results now from this commercial gold, because it is better than they were able to procure before by the acid chemical processes. The platinum is recovered from solution by a simple chemical operation, so that the platinum that used to stay with the gold and be lost is now saved.

Besides tin, lead, silver, copper, and gold, I believe there are other metals to which the electrolytic refining process is quite applicable. This is a large field in which electrometallurgists are already working; antimony and tin, for instance, have been worked on in this way. The general principles explained are applied, with differences in detail, to each one of the metals, enabling one to obtain the purest metals that have ever been put on the market.

If you electrolyze a solution with an insoluble anode, you can extract the metal from the solution without replacing it by metal from the anode. There are a number of promising electrometallurgical processes included in this class of electrolytic processes.

1. When you dissolve the gold from gold ore in potassium cyanide solution, the next problem is to get it out of solution. The

sually done is by chemical deposition by means of c. ectrometallurgical method of extracting gold out of solution was used by Siemens and Halske, in South Africa, but that thod is had a hard struggle to compete with ordinary precipi- ion z . Silver goes with the gold when it is deposited from cy ition.

If you at the water in a copper mine, you will find it is frequently colored blue by sulphate of copper. That solution is usually run over scrap iron or pig iron, to deposit the copper by a chemical reaction; but if you are idling solutions where iron is not available it is possible to e. rolyze it with an insoluble anode and throw down the coppe ite pure on the cathode.

This year we have had news in echnical press of a very great development in this method of king in Chile. The Guggenheim's Chile Exploration Compan as uncovered a large deposit of copper ore near Antofagasta wh is soluble in dilute sulphuric acid. The ore is treated by dilute sulphuric acid, and, by electrolyzing the solution by insoluble odes, the sulphuric acid for further treatment is regained. The main crux of that question was to find an insoluble anode which would not be attacked. Lead was used, but it forms lead peroxide, and gradually falls to pieces; a high-silicon iron was used, but that gradually falls to pieces. In Germany they are now casting magnetic oxide of iron, Fe_3O_4, into the shape of anodes and using them successfully. They are about the shape of flattened baseball bats, hollow inside, with the walls a little over one-fourth inch thick. They are made in Frankfort-on-Main by the Griesheim Elektron Company. The Chile Exploration Company gave the Frankfort firm one order for 90,000 of these electrodes. It is interesting to consider that when they are immersed in the solution, the magnetite itself not being a good conductor, you would have considerable resistance in passing current down to the lower end. This is obviated by electrodepositing a shell of copper on the inside surface, fastening copper strips at the top to conduct the current into the inside shell, and then the only resistance which the current meets is about one-fourth inch of the magnetite to get from the inside to the outside. This work was described by Mr. E. A. Capellin Smith in New York before the American Electrochemical Society, at its twenty-fi meeting in April last. That was the first public the operations in detail. That plant is designed t

tons of ore a day. An immense body of ore is to be treated by this method.

You can get an idea of the importance of these methods of electrolysis with insoluble anodes from the few instances given. These magnetite anodes may also be quite useful in other electrolytic processes. In the generation of oxygen, for instance, they may find it practicable, for there has been trouble with anodes becoming corroded. I saw last summer, in Butte, an operation of the same kind, of the Butte and Duluth Company, plating copper out from sulphate solution and regaining the sulphuric acid for use again. The Phelps Dodge Company, which runs large copper mines in Arizona, has begun to study this method for its lowest grade of ores, and the main solution of this question rests on the use of insoluble anodes of fused magnetite.

We will next consider the question of the *Fused Salts*. In nature we find a number of metals in the state of salts which are fusible and which can be electrolyzed—sodium, calcium, and magnesium are obtained directly by the electrolyzation of those simple salts. Common salt, for instance, is only worth a few dollars a ton. If converted into metallic sodium on the one hand and chlorine gas on the other, one worth several hundred dollars per ton and the other worth fifty dollars a ton, you can see there is a great economic gain. The value of the product is out of all proportion to the cost of the raw material, and the cheapest way to do it is electrolytically. We have, therefore, numerous sodium works manufacturing sodium and chlorine from sodium chloride. Sodium fluoride is a stronger salt than sodium chloride and if mixed with the latter is not decomposed by the current because it is a weaker salt. The sodium fluoride keeps the melting point of the bath down and enables them to work it at a lower temperature, and thus get a better return of sodium. The uses for sodium increase greatly as the price goes down. Up to a couple of years ago, sodium makers were using caustic soda, $NaOH$, costing about $40 a ton. That was costly and increased the price of the sodium, but by going back to the original sodium chloride and finding electrolytic methods by which it could be utilized the cost of the metal has considerably decreased.

Calcium chloride occurs to a small extent in nature, but should properly be classed as an artificial salt. We have here an interesting illustration of another method of electrolyzing a fused salt.

The bath consists of the fused calcium chloride. Calcium is so light that it floats to the surface of the bath, and when it floats it is exposed to the air and is apt to take fire. By putting the cathode just in contact with the upper surface of the electrolyte, the button is deposited against the electrode, and when it reaches a given size the electrode is lifted a little bit. The fused salt sets on it and protects it from the air. By continuing to slowly raise the electrode there is obtained an irregular rod of the metal. You buy the metallic calcium in a stick about one and one-half inches in diameter just as it is drawn away from the surface of the electrolyte.

Metallic magnesium is made in a similar way. With a specific gravity of 1.721 it floats to the surface. I have never seen any made in that way, but I hear that the same firm that makes calcium makes metallic magnesium in the same way.

Cerium is used for Welsbach gas mantles, which contain thorium and cerium oxides. The residue from this manufacture is piled up high in the Welsbach Company's yards at Gloucester; it is about half cerium oxide. Dr. Auer von Welsbach started to see if he could not utilize this residue, and he began by studying the properties of metallic cerium, to see what useful properties it might have. He was impressed by the striking property which it has of giving sparks and found by experiment that by alloying it with iron he could greatly increase the spark-giving property, so as to make it useful in those little cigar-lighters with which we are all familiar. The alloy used in those lighters is made from the waste cerium oxides, dissolved in fused fluorides. It is put into an electrolytic bath in somewhat the same manner as a chloride. The other rare metals (lanthanum, didymium) are allowed to stay in because they do not injure the quality of the alloy.

There is no works manufacturing cerium at the present time in this country, but I visited such a works at Treibach in Austria last year, and I understand that Dr. Fattinger has been over here considering where to put up a plant to manufacture these alloys from the residues which are in the yards at Gloucester, N. J. This industry employs three or four thousand workmen in Austria, and there is no reason why we should not have a similar industry over here.

I mention zinc here because a great deal of money has been spent in trying to manufacture zinc chloride and then to electrolyze it. The idea is to treat those complex sulphide ores which

contain zinc with chlorine gas, converting the zinc into chloride, separating it from the other chlorides, purifying it, and the forming of it a bath, electrolyzing it, and getting back the chlorine, which is used again in the early part of the process. The ores are so complex that the operation has not yet been made a commercial success.

Electrolysis of solutions in fused baths is a principle which was discovered by Mr. Charles M. Hall and has been the foundation of the whole aluminium industry. It costs considerable money to get pure aluminium, but if you do not get it pure it is useless for many purposes. Mr. Hall was trying to decompose alumina, Al_2O_3, electrically, and he conceived the idea that if he could find some fused salt which would dissolve it the problem might be solved. Cryolite from Greenland is used for that purpose. It looks like wax or ice; its name—"cryolite"—means "ice-stone." It fuses at 1000° C. and when fused it is as limpid or clear as distilled water. Alumina dissolves in it like sugar in water. Take such a solution, put electrodes in, pass the current through, and you get out aluminium. You have to replenish the alum na as the supply in the bath becomes depleted. This invention of Mr. Hall is the cornerstone of the whole aluminium industry. There is probably 150,000 horsepower being used to manufacture aluminium. The output last year was something like 65,000 metric tons, of which about 40,000 were manufactured in America. The extent of this infant industry is amazing; it replaces three to four times its weight of the metals with which it is competing, because of its very low specific gravity. The output of copper in this country is now about 500,000 tons a year and is nearly stationery, while the output of aluminium, starting with almost nothing, has been doubling nearly every year. Last year, including Canada, the American output was estimated at 69,000,000 pounds. The commercial importance of this should appeal to us; I believe that aluminium is going to give copper a hard race. There is considerable more margin for reducing the cost of aluminium and selling it at a lower price than there is for copper. When copper gets below eleven cents a pound, many mines have to stop producing, but aluminium can be sold at a profit at a price lower than the cost of one equivalent amount of copper.

We now come to the electro-thermal methods and electric furnaces.

The electric furnace was first used to fuse metals. There are different kinds of electric furnaces; you can class them broadly into resistance furnaces and arc furnaces. Resistance furnaces can be subdivided into the direct resistance furnace and the induction furnace. The direct resistance furnace is one in which the material is heated directly by the passage of the current through it, while in the induction furnace it is heated by an induced current. In the arc furnace, where you use the arc, there is also some heat generated by the resistance of the electrodes, and some by the passage of current in the materials, where the arc jumps to the materials. The resistance of the arc, however, will account for 75 to 90 per cent. of the heat generated.

The fusion of metals was first tried by Siemens in England. He used a little crucible, making the bottom of his crucible one electrode of his furnace and the other terminal an electrode entering from above. He published his paper before the Institute of Telegraphic Engineers in England, because he could find no other scientific society interested in it. He rigged up a little automatic regulator to keep the arc constant, and his idea was to melt steel directly in the crucible, a crucible full at a time, by electric heat. In some of his tests he obtained about 50 per cent. thermal efficiency for the purpose desired, i. e., the heat in the melted steel was some 50 per cent. of the heat equivalent of the electrolytic energy used. His furnace never went into commercial use, but it was followed some twenty years later by the furnace of Mr. Heroult in the Savoy, France, who was the first to have the idea of fusing steel in a large furnace. Girod also constructed a practicable steel melting electric furnace, and there are several forms of successful induction furnaces. Within the next five years Mr. Hering's resistance furnace will also be making steel. Electric furnace steel is rapidly replacing crucible steel; it will probably replace it entirely in the next ten years. All steel could be benefited by a short sojourn in the electric furnace, and the latter will come into large use as an adjunct to the open-hearth steel furnace and the Bessemer converter.

Mr. Hering's resistance furnace uses small pencil-shaped resistors, filled with molten metal, and transfers the heat generated in them to the molten metal bath. The circulation in and out of these resistors is so active, because of the "pinch" force and its attendant "squirt" effect, that their temperature does not get excessive, and

the heat generated in them is rapidly transferred to the main bath. I have seen this furnace working very prettily on brass and cast iron, and I believe it has as promising a future as any electric furnace.

The Stassano furnace is a typical arc radiation furnace. It is usually run by three-phase current, the three arcs being kept clear of the bath of metal, which is heated by direct radiation from the arc or indirect radiation from the roof. The three electrodes are a little above the surface of the bath, at equal angular distances and with an arc springing between them. But in practice the arc may easily pass to the bath because of the metallic vapors produced in an intense heat like that. The air in the furnace becomes quite conductive from silicon, manganese, and iron vapors, so that you can have a 6-inch arc with about 90 volts across the phases; it is similar to a mercury arc.

The induction furnaces, of which there are several variations and types, are a great triumph of metallurgical and engineering art. I have the greatest respect for the man who first built a furnace like a transformer, with only one secondary turn, put a primary right in the centre of that ring, and succeeded in keeping it cool enough so that it did not melt the insulation on the wire, and transmitting the magnetic flux through the intervening space and materials to the metal which was to be melted. I regard the induction furnace as a marvel of engineering construction, and it was fortunate that it has been taken up by the Germans. It was first worked commercially in Sweden, but was devised years before by Mr. Colby, of Newark, N. J., who tried it but did not make it a commercial success. Mr. Kjellin, in Gysinge, Sweden, did it commercially, and then the Germans took hold of it and stuck to it, improved it, and with their great tenacity have overcome the difficulties and made the induction furnace better than I think any other nation could have made it. Many have thought that the induction furnace would drop out of the race, but the German is coming along with some further improvements all the time. It is better adapted for melting and keeping the steel melted than for refining the steel. It is not very well adapted for refining the steel because of the limited surface exposed. The Germans, however, are overcoming even that difficulty and have arranged a large open bath in the centre of their furnace, a bath in the middle where there is room for the action of the chemicals on the steel for refining it.

Mr. Paul Heroult was the first one to melt steel commercially in an electric furnace. He was not a steel maker; he was an electrical engineer, and he used to say, "I do not know anything about steel, but I am going to learn." I think he succeeded by learning some short cuts. You know we frequently are handicapped by knowing too much about a thing. He made a new flux and used the arc; he used it "without knowing that some things could not be done," and he did them. His furnace was nothing more nor less in outline than an open hearth furnace. His idea was to build a tilting open hearth furnace and to put his two electrodes through the roof above the bath. The idea of putting two arcs in series, with the bath as an intermediate conductor, was novel. Heroult patented the idea of melting steel by two electrodes in an electric furnace, passing the two arcs through a layer of silica slag. Mr. Heroult's furnace has been improved upon or modified by Mr. Girod, who uses only one upper electrode and conducts this lower electrode through the hearth of the furnace, so that he has only one arc, and takes off the current through the one electrode running through the hearth of the furnace. These electrodes in action are partly melted, about half way down, and the rest is solid. They are quite permanent; I have seen some of them which ran eighteen months. The steel metallurgist would be the last to dare to make a hole in the hearth of his furnace and put an electrode through the bottom. But that was where the electrical engineer put it, and there has been no trouble whatever with those electrodes. Right where the electrical engineer put them would have been the last place the metallurgist would put them.

Concerning the reduction of compounds to metal in electric furnaces, I have time to pick out only a few characteristic examples.

Boron is one of the rarest metals, but its compounds are abundant. It is made by bringing a volatile boron salt with hydrogen gas into an electric arc, where they are heated to a very high temperature. The salt is reduced by the hydrogen to metal, and the vapors produced are chilled before they have a chance to recombine. It is the same operating principle as is used in the fixation of atmospheric nitrogen in Norway. This boron is being put on the market for use in casting "conductivity" copper. This is one of the most recent productions of the electric furnace.

In Niagara Falls, Mr. Tone is reducing ordinary silica sand, SiO_2, to metallic silicon. This gentleman once took me into the

carborundum works at Niagara, showed me a barrel containing some thing, and told me to guess what it was I made two or three vain guesses, and he finally told me it was silicon, which, he said, "we can make for a few cents a pound." At that time metallic silicon was quoted in commercial price lists at $4.00 a gramme ($18.00 per pound). He said he wanted to find some use for it. Silicon is somewhat volatile, and 25 per cent. of that which he puts into his furnace goes up in smoke. He is now making silicon at Niagara Falls by the ton. Silica is mixed with carbon, put into a furnace heated by a carbon resistor, the mixture of silica and carbon being piled around the resistor, and the metal filters down around this resistor and runs out something like slag. It is being cast into vessels for use in chemical works. Thus is the most abundant element on earth now commercially available at a price of about six or seven cents a pound. One can only speculate as to the large future uses of it; it is made from the cheapest materials; the reducing agent is cheap carbon; and you have metallic silica from the electric furnace.

The zinc industry is attracting a great deal of attention. It is, apparently, one of the least progressive of the metallurgical industries. Little bits of retorts are heated to a high temperature, a few shovelfuls of roasted ore mixed with carbon are put into each retort and left there for 24 hours. Everything is done in a very homeopathic way, and yet it is so difficult a metal to handle that it is only by holding fast the ground gained that it has reached its present status. The electric furnace zinc industry has been made successful in Europe; there are works in profitable operation in Norway, Sweden, and Finland, while much skillful experimenting has been done in America. Last year 4000 horse-power was being used in producing zinc in Scandinavia, and 7000 horse-power has been added since then. The firms are very reticent about their methods; in fact, there is no reliable published data about their present type of furnace.

The manufacture of ferro-manganese, ferro-tungsten, etc., for making special steels, is done almost entirely in the electric furnace. The oxide of iron is mixed with the oxide of the metal to be reduced, with sufficient carbon for reduction. It takes about half a horse-power year to produce a ton of 50 per cent. ferro-silicon, for instance. The chief seat of this industry is the Savoy, in France, but the industry is gaining ground in the United States and Canada, and

imports are decreasing. Stassano, in Turin, was the first to make such alloys, using his arc-radiation furnace, but enormous furnaces (Helfenstein's) of 5000 to 10,000 horse-power are now used in this industry, which thus led up to the electric furnace manufacture of pig-iron and pig-steel.

The manufacture of the cheapest metal we have from the cheapest ore we have by electrometallurgical processes is, I suppose, one of the greatest triumphs of electrometallurgy. The electric current can really be used for doing what is now done in the blast and it is possible under some circumstances to replace it by an electrometallurgical furnace; that is the last triumph of electrometallurgy.

In one little place in Sweden that I visited two years ago, charcoal was getting scarce and they were importing coke from England to run their blast furnaces, and the quality of the product was not that of iron made with charcoal. They were much interested in the electric furnace, because it requires only one-third as much fuel to make a ton of pig-iron as the blast furnace. In their blast furnaces, with the charcoal available, they could make 300,000 tons of pig-iron, but in the electric furnace they could make 900,000 tons with the same fuel; so that was one of the inducements to use the electric furnace. The Swedes spent a quarter of a million dollars before they had a successful working furnace. They did their work in a most scientific way all through, watched their temperatures and all the conditions, and knew exactly what they were doing all the time. As a net result, they made pig-iron in the electric furnace as cheaply as they can in their blast furnaces. The Jern Kontoret (Iron Masters' Society) bought the patents for the furnaces, so that they became the common property of all the ironmasters of Sweden, and they have been putting up furnaces pretty rapidly. The last one was designed for 12,000 horse-power. It has been running for nearly a year at from 6000 to 8000 horse-power, making 55 tons of pig-iron per day. If it were run at full capacity, I think they could make 100 tons a day, which is equal to the average capacity of one of their blast furnaces.

At Domnarfvet and Hagfors, in Sweden, the same thing is pending. At the latter works they calculate that with this large furnace there is a margin of $2.50 per ton on the cost of pig-iron, to the advantage of the electrical furnace over their blast furnaces, so that electric furnace pig-iron is being made at a profit and cheaper than it could be made in the blast furnace in Sweden.

The possibility of making a product from this furnace which is not pig-iron, but which, as far as carbon content is concerned, will have to be classed as steel, has been proved. That product, with less than two per cent. of carbon, is in reality impure steel and not cast iron. It requires only a small amount of refining to bring it to pure steel. With the excess of iron ore present in the furnace you can make a low-carbon product. With electricity to furnish the heat, you can regulate the carbon so as to make a product with only two per cent. of carbon. This is a possibility with an electric furnace, but it is not a possibility with the blast furnace. We can thus make pig-steel, with less than two per cent. carbon, which can be converted in the open-hearth furnace into pure steel in about half the time that the ordinary product of the blast furnace takes. This will bring advantages with which the blast furnace cannot possibly compete. In the case of the problem being worked out, pig-steel will replace pig-iron for the manufacture of steel; this opens up the possibility of the electric reduction of iron ore going into use in places where otherwise it would not go if the product were simply pig-iron. It may come into Canada or along our northern borders, where water power can be obtained cheaply, for there is the large expenditure of 3000 horse-power hours per ton of product to be reckoned with. This will be the next great advance in the electrometallurgy of iron and steel.

DISCUSSION

A MEMBER.—I would like to ask why, in the reduction of silicon, the resistor is not consumed as well as the carbon which is used for reducing the silicon?

A. The resistor does get corroded, but the mixture contains sufficient carbon to take all the oxygen of the silica. Undoubtedly some silica gets against the resistor and eventually it corrodes away, but there is always more than enough carbon used.

MR. HENRY HESS.—I have a few questions on which I would like a little information:

The question of charging a furnace was brought up. Electric steel furnaces are mostly charged with cold metal. I was told somewhere that the use of molten metal would be better.

I think Professor Richards spoke of the Stassano furnace, of the current going down in the bath rather than between the two electrodes. We have a little furnace, and we found the trouble particularly great when the cold charges have been put in, and allowing the heat to get up fairly high; but when the charge is once liquid and kept down to the level at which it ought to be kept there is practically no jumping of the arc. The electric one-ton furnace that we have is

supposed to run with 1100 K. W. with cold metal and with a cold furnace, and for the second and third charge they were started with 900. The expectation is that it will run lower than that, to about 700 when it is working in good order, but the guarantee is for 900.

There has been recently an effort to improve the furnace. It is a very simple furnace apparently. It has only one top electrode dipping into the bath, and one bottom electrode. The figures given for that were 500 K. W. H. per ton. That does seem to me to be something extraordinary Is that a possibility in these days for a one-ton furnace? It is true they would give no guarantee as to the refining action of the metal it would take out.

Referring to the last possibility, pig steel; that is called impure pig steel; but since rather impure materials compared with what you want to get out are put into an electric furnace, and you can in that furnace refine to almost any degree you wish, why is it not practicable to carry that pig steel to a further degree and put it into the electric furnace again? Why not go direct to that?

PROF. RICHARDS.—The reason it is not done directly is because the steel furnace is essentially worked intermittently. You make your steel in batches, and when you have it right you pour it out. This furnace is worked continuously, and you cannot obtain a product like that; it requires an intermittent process.

MR. HESS.—Why don't they pour it into another one?

PROF. RICHARDS.—They do that. The steel was made from the cold metal but it could just as well be put in fluid. They are building electric steel furnaces alongside the other furnaces to take the product direct.

As for the requirement of 500 K. W. hours per ton of steel in Mr. Snyder's furnace, I think that is entirely possible. The heat insulation is well studied out, and it takes practically 375 K. W. H. net to melt a ton of steel; if they use 550 they are getting an efficiency of something like 70 per cent. That does not, however, leave much time for refining.

As to the work in the Stasanno furnace, if the electrodes are high enough above the bath and close enough together, the arc keeps clear of the bath; but when the arc jumps to the bath, as it does in Mr. Heroult's, then you have the principle of the Heroult furnace—arcs in series, with the bath as intermediate conductor.

You have asked whether the use of partly refined liquid metal in the electric furnace is patented. Mr. Heroult claimed that it was covered by his patent. He asked me out to see his furnace in Chicago, and I took the stand with Mr. Heroult at that time that his patent did not cover it, and I am still of the same opinion. He stated positively that it covered it, but I have studied the patent situation very carefully, and I have come to the conclusion that it does not.

DR. H. M. CHANCE.—I would like to ask Professor Richards whether he has any data on the consumption of electric energy in the operation of large furnaces, in the refining processes?

A. It depends on how long the refining lasts. If it lasts one and a half hours on fifteen tons, then it would take 1500 K. W. hours. That is 100 K. W. per hour per ton. If the operation lasted two hours, then it would take 200 K. W. hours per ton. With larger furnaces, properly heat-jacketed, it should be run with about half this heat requirement. I believe some of the large furnaces abroad are

using as low as 65 K. W. per ton to keep the steel melted, without raising the temperature. That includes the necessary refining operation, which lasts one hour. This is the lowest I have seen.

MR. HESS.—Referring to the heat jacketing; that furnace we have there, you can, primarily, almost keep your hand on it throughout the entire operation of the furnace, and we attribute the greater heat in the vicinity of the doors rather to the induction in the flue of the doors rather than in the induction of the material. And the losses in keeping the electrode holders cool are not very great, having a running stream of about one-half inch at twenty pounds pressure. It is fairly warm above the ordinary temperature. That is not taking off any enormous amount of heat.

DR. CHANCE.—With the electric consumption of energy, amounting to 2400 K. W. H. for the production of pig iron, how is it possible to harmonize this, with the statement that it looks as though the electric furnace was to replace the ordinary blast furnace in the near future. If we have our electrical energy at no cost, even at one and one-half cents per K. W. H., we have a cost of $12 per ton electric energy. The cost of blast furnace fuel is less than that.

A. The cost of fuel in blast furnaces in Sweden is about $5 per ton, and the cost of electric furnace power is one-tenth of a cent per K. W. hour. That is also what it costs in Norway.

DR. CHANCE.—I do not think we can hope for anything like that in this country.

PROF. RICHARDS.—You can purchase in Norway any amount you want at one-tenth of a cent per H. P. hour. In that connection in may be interesting to state that the actual cost of power in Norway, in the larger plants, is somewhere between $4.00 and $5.00 per H. P. year. It costs a little more in Sweden because the water falls are greater in volume but not so high, and the installation cost is higher. The power in Sweden costs ordinarily from $7.00 to $10.00 per H. P. year. You can buy it at $12 per H. P. year from the government, but the costs average nearly 50% higher than in Norway, where the cost of development is very small and is from lakes just a little way back from the sea at a great height, and the installation can be made at minimum cost.

MR. HESS.—There are electric public utility corporations who sell electric current at something under one-half cent to small users in this country.

Q. Where?

MR. HESS.—In Detroit for one place.

DR. CHANCE.—At those places, where you have used nominally low costs and where they have surplus power to sell, as a rule they can find no consumers. In this country we have water powers existing, and the owners of such water powers can usually find a market at a much larger price than you quote. The question I asked had reference to this country. We have a market for electrical energy in this country, and it costs something to develop it, and I do not think you will find many hydro-electric companies of this country willing to furnish power at much less than 3 or 4 cents per H. P.

PROF. RICHARDS.—I know several places in this country where it costs $7.00 to $8.00 per H. P. year; that is for self costs.

Dr. Chance.—At Sault Ste. Marie they advertise power.

Mr. Swaab.—The P. R. T. in this city say they produce current for 0.6 cents, but that is without the overhead.

Mr. ———.—I would like to have described the degree of purity obtained in the manufacture of tungsten and the use of alloys in the manufacture of so-called high speed steels.

Prof. Richards.—If you mix the tungsten oxide with iron oxide and sufficient carbon and put them into an electric furnace, you get a ferro-tungsten rather high in carbon. It is not suitable for making a low-carbon steel product, for which you need a low carbon ferro-tungsten, but this carbon can be burned out by the use of more oxide of iron. By the use of aluminium and in the absence of carbon, a low-carbon ferro-tungsten; the best is probably made by the Goldschmidt method.

Mr. Chance, Jr.—There is one point which I think is hardly fair to hydro-electric propositions. We are interested in a water power of 300 feet head, and there is a chance there for electric furnace construction. We cannot do much better than $120.00 per K. W. as the cost of installation, or a total at $9.60 per K. W. year, with insurance, etc., if you do not figure any thing on your maintenance, and one per cent. load factor, so we cannot get anything like one-tenth of a cent per K. W. H. But I think there is a chance to bring the furnace into use, especially in a case of this kind. When the iron market gets bad, you have to buy your current and pay for it. If it were possible to put in a furnace making pig steel, there might be a possibility to work it commercially. We have a case in Northern New York of an electric furnace that is making alloys, and we understood that they could take anything and put it into the furnace and get just about what was wanted out of it, at low costs. I would like to know whether this has been experienced by others?

Prof. Richards.—Conditions in this country at the present time are not favorable in general to making electric furnace pig-iron, but I think there are a few localities where it may be favorable for making pig-steel. There is a plant in North California which is making electric furnace pig-iron at a low cost. It is possible to use a high phosphorus ore and get a low phosphorus product, because the crucible is lined with basic bricks.

Mr. Chance, Jr.—You said that with 8,000 H. P. the output was 55 tons a day. That figures out about 35 H. P. per ton.

Prof. Richards.—If my memory serves me, I said that from 6000 to 8000 H. P. had been used, and the output averaged 55 tons a day. It figures out something like 3000 H. P. hours, or 2400 K. W. hours per ton. It is a striking example of how not to run an electric furnace, because if you run a furnace at half its capacity its specific power consumption is going to run up enormously. That furnace run to its capacity would probably make 120 tons a day at 2500 H. P. hours per ton.

Dr. Chance.—We have recently had before us some little problems of this kind. Up in New York State we have charge of a mine producing a very high grade concentrate. For feeding an electric furnace, we could run the concentra-

tration up to 69% product, so we would only have 3 or 4% impurities in that ore to take care of. That ore is extremely low phosphorus. Whether we run the concentration up to 69 or 70%, we get .606, so that the ore will produce what is known as a low phosphorus pig; we pass down below the decimal limit of phosphorus, and we can get it about as low as water powers usually can. There is a concern at Plattsburg, N. Y., and they have made some very beautiful metal from our concentrates. We have gone into the matter at considerable length, and we cannot see exactly where there could possibly be any profit in the operation unless the current can be utilized at times when it was not needed for other purposes. Unless we could utilize the electric furnace for other purposes when it was not required, then it might make out all right under present conditions, but as a straight out proposition we have not been able to see our way in advising people to spend their money in experiments of this kind.

Prof. Richards.—How much does that power cost you?

A. 0.4 cent.

Prof. Richards.—0.4 cent is $35.00 per K. W. year, which is something like $26.00 per H. P. year, and you can buy power at Niagara for $25.00 at the upper Falls, and $15.00 in the lower Falls, and you can go to Welland and buy it for $12.00.

Mr. Chance, Jr.—Yes, but we have to buy our current and we have to figure our total power product on our load factor.

Dr. Carl Hering.—If you have power to sell, you sell all that you can for lighting and traction purposes, because that is required for certain hours of the day when you can get high prices for it, and they sell the power required for light load for electro-chemical processes for less than 0.5 cent per K. W. H.

Prof. Richards.—I know of a small furnace which is making steel castings at a profit, and the power costs one cent per K. W. H., but there are electro-chemical works which could pay one cent per K. W. H. and make a profit.

Dr. Hering.—There are concerns in Pennsylvania which can sell power for half a cent for traction purposes; but it does pay to let your furnace cool down.

Mr. Hess.—I am buying current intermittently now. Our contract is 1.25 cent per K. W. H. for the regular use of the plant. For the current used in the furnace, except in winter, from 5 to 11 P. M., we can get them down to something like .8 cents per K. W., and they are willing to furnish us that from a small plant, and when we are using that we are taking more than half their entire product. They are willing to put in more plant to take care of us. And it is one of our public utility corporations, and I do not think we will accuse them of running a philanthropic scheme.

Mr. Harold Goodwin, Jr.—I wanted to speak of the off-peak business between the hours of 4.30 and 5 to 7 o'clock in the evening, especially in the fall and early winter. The rest of the time they have that capacity standing idle. The electric furnace has the disadvantage which Mr. Hering has spoken of, in having to keep up the heat for that period. I would like to ask about the electrometallurgical process, particularly that of copper refining, whether the tempera-

ture has any influence upon it, and how that temperature is to be maintained. In the winter you have to house in your tank so as to keep it at absolutely constant temperature, and that brings up the question as to how you could drop off that load so as to avoid the peak at the central station; would they simply pull the switches on the feeders when their load ran up, or would that upset the electrolytic process so that the copper would not be deposited pure?

He also spoke of calcium. I would like to know whether any progress has been made in the use of metallic calcium. I think it stands quite high in the electrical schedule of conductivity, and it is very cheap, and if it were properly alloyed with other metals it would make a very cheap electrical conductor.

PROF. RICHARDS.—The crux of electric copper refining is that the current density should not exceed a certain limit. You can drop to one-half or one-quarter of this limit and produce very pure copper. If you get above the limit, you get impure copper. You could cut down the current at peak hours with no disadvantages except decreased output to balance against cheaper power. Almost all the copper refining companies are such large consumers that they generate their own power. The Superintendent of the Chrone, N. J., works said that they were producing power in New York Harbor, using buckwheat coal at $2.00 per ton and triple expansion engines at 0.35 cents per K. W. H., at Perth Amboy; that is cost price.

MR. GOODWIN.—Then the concentrated working under those same conditions ought to be able to cut down the price to 0.3 cents if they can sell that peak up to .10 cents per K. W. H. You say it is all right to cut down the current, but suppose it were cut off and the tanks allowed to cool?

A. They can be cooled down for hours with very little difference. They would not cool perceptibly. It would simply cut down the output of the plant.

MR. GOODWIN.—Suppose it were necessary to cut the current off every day for three months, which would equal 120 days a year at 4 hours, which is one-sixth; that would be equivalent to cutting out the supply for 20 days. That would be a reduction in the total of a little over 3 per cent. and would reduce the output that much, and they could make a considerable reduction in the price of current.

MR. HESS.—There is a reason why current in the country cannot be furnished as cheaply as it might be. When a large corporation is used to getting anything from 15 cents to 6.6 cents as a minimum, they are not going to encourage anybody in the idea that current can be furnished in any part whatever at anything like half a cent.

PAPER No. 1144

THE WATER SUPPLY OF ANCIENT JERUSALEM

By HENRY LEFFMANN

October 3, 1914

Recent investigations have shown that Jerusalem was a point of great strategic importance at an early date. The origin and meaning of the name have not been positively established. The city has suffered, probably, more severe vicissitudes than any other city of the ancient or modern world. It has been the object of many sieges, and has been often captured and practically destroyed. In the second century of the common era, its inhabitants were involved in a rebellion against the Roman Empire, and it was taken by the Emperor Hadrian, who determined to annihilate it forever, drew the ploughshare over it, and re-named the site "Aelia Capitolina," but this effort failed, and the name is known only to the antiquarian and historian. An interesting fact stands out in the history of its sieges, namely, that, although the inhabitants suffered much from lack of food, they had abundance of water, while the besiegers as a rule had the reverse conditions. The region around Jerusalem is very sparsely watered, and, at an early date in the Jewish occupation of the city, means were taken to secure water supply within the walls and also to divert any supplies from without.

Information concerning the water supply of ancient Jerusalem is obtained partly from the Hebrew and Greek scriptures, but largely from the results of excavations, especially those carried out under the auspices of the Palestine Exploration Fund, the quarterly reports of which contain a large amount of interesting data. A number of comprehensive works are also available. Maps, topographic, geologic, and of other types, have been issued. Of late years, facilities for tourists have been greatly increased, so that thousands of visitors from all parts of the civilized world are constantly streaming through its gates. It is well known that the railroad leading from the coast to Jerusalem is operated by locomotives built at the Baldwin Works.

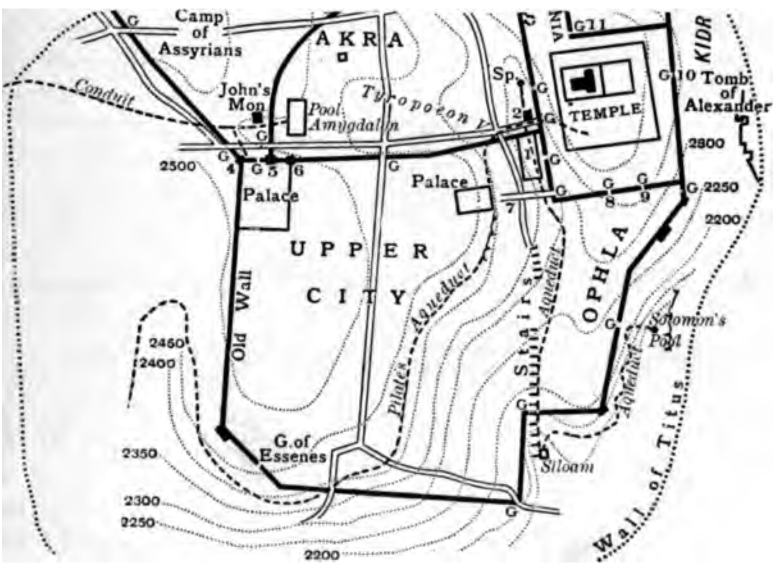
Jerusalem lies upon what may be called a coast range, about 2400 feet above sea level and about 30 miles east of the Mediterranean shore. Seldom do we find as good an example of the relation between physical geography and the history of a people as in Palestine. The territory first occupied by the Israelites is about about 200 miles long and, at its widest part, about 70 miles. Though located in large part on the Mediterranean side of the coast range, the Jewish nation, even in the reigns of David and Solomon, when Jerusalem showed all the grandeur of oriental absolutism, never acquired a status as a commercial power. The reason is that the territory had no harbors. From the summit of the divide, a height of nearly 2600 feet, the Plain of Sharon descends to the Mediterranean shore, but within Jewish dominions this shore offers no shelter for even the small craft of the ancient world. During the entire period of Jewish dominion, the commercial opportunities of the Palestine coast were under the control of hostile nations, on the south the Philistines, on the north the Phenicians. The latter, as is well known, occupy a conspicuous place in the commercial history of the Mediterranean basin, having at a very early period pushed their sailings to the European coast of the Atlantic. Phenician sailors entered the employment of other nations. Several hundred years before the beginning of the present era, Phenicians in the service of one of the Egyptian kings made a circuit of the continent of Africa. The commercial supremacy of Phenicia, especially of Tyre, finds vivid expression in several places in the Old Testament, notably in the 27th chapter of Ezekiel, in which the city is compared to a ship and its fall and desolation predicted.

An interesting point is that the Dead Sea, which lies but a few miles to the east, is the lowest inhabited point on the earth's surface, being about 1300 feet below the Mediterranean datum.

It is obvious that no large supply of potable surface water could be secured from such a region. Reliance must be placed on subsoil or rain water. Both sources have some objectionable features. Subsoil waters are often rich in mineral matter, and in populated regions are liable to serious contamination. Rain water, though nominally distilled, is contaminated with suspended matters from the air and roofs, and is rarely of high purity in a practical sanitary sense. Ancient engineers knew almost nothing about the manner in which water produces disease and had no methods of purification except storage or by use of interrupting chambers that would

mit some subsidence. Interesting examples of the latter are seen in the Roman Aqueducts, and are figured in my paper on the "Water Supply of Rome," published in a former number of the Proceedings of this Club (Vol. XIII, No. 2).

It is believed by the authorities that the earliest efforts at impounding natural waters for supplying Jerusalem were in Solomon's time (1000 B. C.). A reservoir was built in the Kedron valley—east and southeast of Jerusalem—for supplying water to the royal

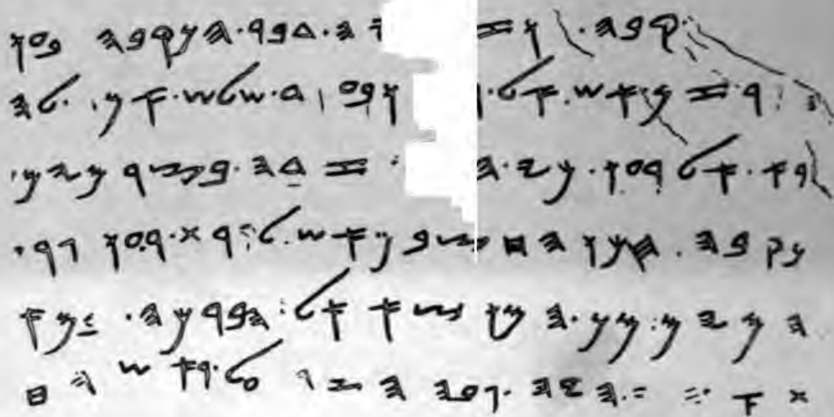


Map of Southern part of Jerusalem at the time of the siege by Titus (about 70 A. D.).

The early conduit is shown in the upper left hand corner, the tunnel of Hezekiah in the lower right hand corner and also the possible course of Pilate's Aqueduct. (From Conder's Jerusalem.)

gardens. This reservoir, called by Josephus (War Bk. 5, chapter 2) Solomon's Pool, has not been identified. Later, an open channel was cut in the rock of the west slope of the Kedron valley, by which water was led to a point at which it was available to the inhabitants of the city. It has been suggested that the text in Isaiah viii.6, "the waters of Shiloh that go softly," is an allusion to the flow in this conduit, which has a slight grade. The original channel was identified in 1866.

A m resting and imposing work was carried out, some three
ıd after Solomon, by King Hezekiah (720 B. C.), who,
r ssyrian invasion, impounded the water of a spring east
h d brought it down to a convenient point. This work
me ot in both accounts of Hezekiah's reign. Thus, in II
ve read: "Now the rest of the acts of Hezekiah and all
s m d how he made the pool and conduit, and brought water to the city, are they not written in the book of the Chronicles of the Kings of Judah?" Turning to II Chronicles xxxii. 30, we read that Hezekiah "stopped per spring of the waters of Gihon and brought them strai n to the west side of the city of David."



Part of Siloam Inscription (about B. C. 720).

Palestine archeologists regard Gihon as identical with a spring now just outside the city wall and termed the Fountain of the Virgin. The operation of Hezekiah involved the cutting of a tunnel through rock for about one thousand feet in a tortuous course by which water was led into two reservoirs near the southeast corner of the city. About thirty years ago this tunnel was explored and an inscription was found on the wall near the lower opening. The language is old Hebrew. Some imperfections exist and portions of the translation have to be supplied by inference, but the main tenor of the statement is clear. One word has bee of dispute among the authorities, and I venture to tion of my own concerning its meaning. The read

"End of the Boring. Here is an account is the boring. While the borers worked their picks in opposite directions and there were three cubits to break through, they heard each other's voices, for there was an overlap found in the rock on the right and left, and on the day of completion the borers faced each other face to face. The waters ran from the pool spring twelve hundred cubits. The height of the rock above the borers' heads was one cubit."

My suggestion relates to the word "overlap." The word in the original is uncertain and several meanings have been proposed. It seems to me that the translation I give meets the conditions. From the illustration it will be seen that the tunnel pursues a remarkably tortuous course. The only explanation that has been offered for this course is that it was necessary to avoid rock tombs that had already been established.

The spring was intermittent and has even been supposed to have symbolic periodicity. It is an interesting example of how a legend may arise and be propagated that a traveler who visited Jerusalem in the year 333 of the common era, and who is known to historians as the Bordeaux Pilgrim, states that the pool was inside the walls of the city and water did not flow on the Sabbath.

Excavations along the southern wall of Jerusalem have brought to light an aqueduct passing along the northern slope of the Hinnom valley, penetrating the wall and passing to the southwest corner of the city. This aqueduct is well built, being hewn out of a rock-side with rather steep incline, the upper and lower sides being extended by walls so that flat stone covers might be used. The cross section of the channel is rectangular, with a depression in the center line of the floor. The dimensions are about three feet high and two and one-fourth feet wide. Rock-hewn manholes are provided. At one point there is a chamber five and one-fourth feet wide, four feet long, nine feet high. F. J. Bliss, whose excellent work on the excavations at Jerusalem gives much information, thinks that this dates from Solomon's time, but further investigation is required to decide this point.

In addition to these aqueducts, Bliss gives the lines of one beginning on the west of the city, passing around by the south in the Hinnom valley, and entering the city towards the east. This he terms the "Lower-water" aqueduct, but gives no special information about it.

We know from the historian Josephus that Pontius Pilate constructed or repaired an aqueduct at Jerusalem, the possible line of

which is indicated in the annexed map. The text of Josephus is as follows (*Ant*, book 18, chapter 3): "But Pilate undertook to bring a stream of water into Jerusalem and did it with the sacred money, drawing the source of the stream from a distance of two hundred stadia. However, the Jews were not pleased with what had been done about this water, and great crowds of people got together and made a clamor against him and insisted that he should leave off that design. Some of them also used reproaches and abused the man as crowds of such people often do."

Pontius Pilate has been anathema for so many years that we ought to set in his favor the fact that he seems to have appreciated what was at that time "the needs of the water supply of Jerusalem" and endeavored to improve the sanitary condition of the Holy City.

Ancient cities had many objectionable features, but it is evident that even in remote antiquity the question of water supply was regarded as most important. In the story of the Garden of Eden great stress is laid on the abundance of water. Rome, it is well known, had an extensive series of aqueducts, and wherever the Romans established important settlements they provided facilities for a copious supply of good water. From the recently discovered manuscript of Aristotle's Constitution of Athens, we learn that one of the officials of that city was a "Superintendent of Springs." The great vicissitudes that have marked the history of Jerusalem have obliterated much of its earlier constructions, and there has been no intelligent historian to collect and transmit to our own time any detailed account of the engineering methods. By a fortunate circumstance, a manuscript about eight hundred years old, preserved in a Benedictine convent, has enabled us to appreciate the manner in which the Eternal City, in its rise, grandeur, and decay, dealt with the problem of supplying water to a community of many thousands of highly civilized persons, but no Frontinus is known who might give us similar information about the Holy City. Sad, indeed, has been the treatment Rome has received in the course of human history.

> "The Goth, the Christian, time, war, flood, and fire
> Have sat upon the seven city's pride."

But Jerusalem has suffered much more, and today investigations are carried on amid an indifferent and even hostile population, through masses of rubbish that have been accumulating f
three thousand years, and after many occupations by hos
that have hardly left one stone upon another.

ABSTRACT OF MINUTES OF THE CLUB

Business Meeting, June 6, 1914.

The meeting was called to order by President Swaab with 41 members and visitors attendance.

The Committee on Nominations, consisting of Carl Hering, chairman, Richard Gilpin, Richard G. Develin, Richard L. Humphrey, Thomas C. McBride, E. M. Evans, and W. P Dallett, appointed by the Board of Governors at their meetings of May 12, 1914, was accepted.

Owing to the inability of Mr. H. V. Schreiber to be present, Mr. Thomas H. Arnold read Mr. Schreiber's paper, entitled "The Power Problem in the Lehigh District," and then read his paper, entitled "An Analysis of Electric Drive in Cement Mills."

The papers were discussed by Messrs. Hering, Wood, and by Mr. Brooks, of the Lehigh Navigation and Electric Company.

A unanimous vote of thanks was tendered Mr. Arnold.

Joint Meeting

Of the American Society of Engineers, Architects, and Constructors and the Engineers' Club, September 19, 1914:

Meeting was called to order by Vice-President Mebus, at 8:30 P. M., with 112 visitors and members in attendance.

The Secretary announced that the Board of Governors, at their regular meeting of September 15, had elected to active membership the following:

Frederick Lennig, D. Webster Anders, John H. Brown, Jr., and Addison Hutton Savery.

Mr. T. Hugh Boorman presented the paper of the evening, "Modern Road Building Here and Abroad," which was discussed by Messrs. Trautwine, Uhler, Furber, Boorman, and others.

ABSTRACT OF MINUTES OF THE BOARD OF GOVERNORS

Regular Meeting, September 15, 1914.

Present: President Swaab, Vice President Mebus, Directors Berry, Haldeman, Yarnall, Hibbs, Wagner, Worley, Andrews, Dunlap, the Secretary, and the Treasurer.

The minutes of the Regular Meeting of May 12, 1914, were read and approved.

The Treasurer reported a net loss to September 1 of $202.45, as compared to a net gain of $2160.65 for the same period of last year.

A copy of the comparative income and expense statement was presented and the Board ordered that a copy be stricken-off for each member of the Board.

The Treasurer was authorized to bond the bookkeeper for the sum of $2500.00.

The President appointed a Committee, consisting of J. R. Bailey, Chairman, Joseph C. Wagner, and F. K. Worley, to make studies for the purpose of revising the system of bookkeeping in the Club.

The report of the House Committee was presented and appropriation of $100.00 was made for the purpose of purchasing linens for the house and restaurant.

The Membership Committee's report was presented and the following were elected to Active Membership: D. Webster Anders, John A. Brown, Jr., Addison Hutton Savery.

Mr. Yarnall, for the Committee on Co-operation, outlined the progress of the work and the methods which the Committee was pursuing.

It was moved and carried that an exchange of Club privileges be effected with the Engineers' Club of Dayton, Ohio, and the Engineers' Club of Trenton, N. J.

Application from the Delaware River Branch of the American Society of Marine Draftsmen was presented, asking for desk room in the Club house for the use of the Secretary, without charge. This was granted.

The resignations of H. V. Atkinson and Thomas E. Rodman were accepted as of June 30, 1914.

James Thompson's resignation was accepted as of December 31, 1913.

INDEX VOLUME XXXI*

*The January issue of 1914 was numbered Vol. XXXI, No. 5, and should have been numbered Vol. XXXI, No. 1.

PROCEEDINGS

OF

THE ENGINEERS' CLUB

OF PHILADELPHIA

VOLUME XXXII

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OF

THE ENGINEERS' CLUB

OF PHILADELPHIA

ORGANIZED DECEMBER 17, 1877. INCORPORATED JUNE 9, 1892.

NOTE—The Club, as a body, is not responsible for the statements and opinions advanced in its publications.

Vol. XXXII JANUARY, 1915. No. 1

PAPER NO. 1145

AIR CONDITIONING

BY J. IRVINE LYLE

October 17, 1914

In these times when we hear so much about "Back to Nature" it is well to consider what nature gives us in the way of health. We men cannot improve very much on nature's best. Of course, if you pick out a bright sunshiny day in June, you would consider that as being about right. On the other hand, when we stop to consider a cold, bleak, humid day in winter, or a hot, sultry day in summer, I am inclined to think we can improve a little on nature. We cannot beat nature on a June day, but we can give June days the year round if we so make up our minds.

On the question of ventilation there has been quite a discussion in the last few years as to what we needed to improve ventilation. Such men as Briggs, Wolfe, and others have evolved certain standards which are almost universally used. There have been certain documents published by the health authorities, physicians, and others, and the problem has been attacked from various viewpoints; but so far all have failed to prove that the standards that have been adopted are wrong, or to provide a rational substitute for them. Some of them have recommended recirculation of air —of small quantities of air—and this leads one to wonder whether

they have ever considered air in the same way we consider water for drinking.

I want to ask here, how many of you have ever given consideration to the quantity of dilution you would put in your urine before you drank it? That is what we are up against in this air proposition. If we draw our air from one vessel and exhale it into another, the problem is very simple. In a crowded room, our air supply is taken from the room and exhaled into it, thereby making a cesspool of the room. All that we can do with ventilation is to get the air diluted and keep it diluted to the proper point, and even then we are a long way from purity. In this discussion, however, there have been a few well-defined facts brought out, one of which is dust, a second humidity, and a third temperature.

The anti-tuberculosis movement has done more than anything else to acquaint the general public with the necessities for the removal of dust from the air which we breathe. Bacteria, as you know, only multiply and germinate where they are in contact with moisture; but bacteria that are clinging to dust lie in a dormant condition, and when finally meeting something moist they begin to multiply, and for this reason all kinds of bacteria are carried around on dust particles and can be conveyed from one person to another, and they form one of the greatest sources of contagion that exists. Bacteria that are kept moist are rarely ever found floating in the air. For instance, our sewers are full of bacteria, but there are no healthier men than those working in the sewers. Why? There is no danger to them from bacteria, because the bacteria cling to the moist surfaces and there is no dust to convey them to the people working in the sewers; so as long as we keep the surfaces moist, the bacteria are harmless.

Another source of injury to health from dust is when it falls on hot surfaces. Dust exposed to a surface having a temperature of 160 degrees or above, especially organic matter, is decomposed, giving off ammonia, monoxide, and other gases which are detrimental to health, and that is a matter for most serious consideration. The odor so objectionable when we start up our heating systems in the fall is the accumulation of the dust of summer being distilled. It is going on throughout the winter also, but at a much slower rate, and is not so noticeable.

The effect of humidity on health has had a very wide discussion as to just what are the best relative humidities for the human

being, and there are no very close limits. There is no evidence that a man needs an exact humidity; but this does not prove that low humidities or high humidities are objectionable. Take our ordinarily heated homes, where no provision is made for artificial humidification; we often find conditions where the humidity is less than 15 or 20 per cent. I have found in offices as low as 11 per cent. and also in my own home. When we compare this with nature, nature has a little the best of us, because nature never gives us anything quite as dry as that. Take our deserts of Africa or other dry climates; take Arizona, for instance—the average humidity is something like 35 per cent. The low humidities dry up the mucous membranes of our throat and nose, and if it does not produce a diseased condition, it irritates these mucous membranes so greatly that they are easily attacked by disease germs of catarrh and other nasal diseases. Catarrh is the most prevalent disease in this country; it is more universal here than in any other country. Catarrh has been known since Milton's time; it is mentioned in "Paradise Lost" as one of the diseases afflicting men. It has been a very widespread and prevalent disease, and the reason for it is that, for instance, in winter time we enter the house and go into a room where we have a summer temperature and dry atmosphere, and the evaporation from our mucous membrane of the throat and nose is very rapid. Then we go out into a cold atmosphere with a high humidity and immediately reverse the conditions. We have then given those mucous membranes a high humidity to work against. This causes irritation and makes it liable to all kinds of diseases which affect those parts.

There is much less dust floating in the air where the humidities are maintained normal, say 40 to 50 per cent. Some very interesting experiments were carried on by the Government in Pittsburgh a few years ago which proved this statement very conclusively. In connection with the Department of Mines they built a cylinder about 100 feet long and some 6 or 8 feet in diameter, with shelves on the sides upon which they could sprinkle powdered coal. One end of the cylinder was closed, and through this end they inserted the muzzle of a cannon with a bench just in front of it. They subjected the interior of the cylinder to various humidities, and then fired the cannon, making note of the distance the flame from the cylinder would be carried. They found that when they exposed the coal to 80 per cent. humidity the dust on

the shelves would not ignite. They would simply burn the dust on the bench immediately in front of the ignition flame, but on the shelves further, where it had been exposed to 80 per cent. humidity, it would not ignite. This was due to the absence of dust floating in the air.

In this country the heating of our homes, factories, etc., is so universal that the question of heating need not be discussed. The question of cooling of buildings, however, is one that has received very much more study in the last few years than it had previously. Previously, the cost of cooling has been prohibitive, and also the cost of operation, but the advancement of science and new apparatus which has been designed has materially changed that condition. The advantages of cooling are, of course, self-evident. If it pays to heat a building in winter time, it will also pay to cool it off in summer. We will all be in better health if we are not subjected to extreme temperatures. In the past, cooling has been accomplished by refrigeration, and it has been done by passing air to be cooled and used in the building over large banks of coils, using either cold brine or ammonia expansion. These systems have been—some of them—very efficient, but they have the disadvantage of taking up large spaces costing a good deal of money, and with a heavy operating expense. A somewhat newer method has been the use of refrigeration for cooling the water, using the water as a medium instead of brine, spraying the water in direct contact with the air, raising the water temperature and lowering the air temperature, and in this manner somewhat increasing the efficiency of the refrigerating machine so that a smaller machine would do the same amount of work as a larger one, with a reduction in power.

A third method is the cooling by evaporation. We know we cannot evaporate water without supplying the latent heat. If water in evaporating cannot get the latent heat from any other source, it will be taken from the air. This method has been used in textile mills, office buildings, store buildings, and others. Take a large textile mill in which half a million cubic feet of air per minue will be delivered to the building, and the cooling can be done by three gallons of water per minute, which makes the operating cost from a refrigerating standpoint almost nothing.

Of course, cooling by this method increases the humidity, and this brings up the question as to whether in hot weather an increase

in humidity is not objectionable. That is one of the questions regarding humidity which has not been answered to the satisfaction of every-one, but it has been satisfactorily answered from my standpoint. We can take a plant—for instance, take a textile mill as an illustration—a picture of which I will show you later. With a temperature of 103 degrees outside, in July of this year, they had the spinning room at 77°. Outside the humidity was something like 41 per cent.; inside the humidity was 60 per cent. They had 26° difference in temperature, and something like 20 per cent. difference in humidity. In contrast to that was another mill

FIG. 1.

almost identical in every way and operated by the same people where the temperature was 111° inside, being 8° higher than the outside temperature, as against 26° below in the other mill. I believe the best proof I can give you as to whether it would be more comfortable or not so is that these people were threatened with a strike if they did not equip the next room in the same way with cooling apparatus.

I could give you a number of instances where as high as 80 per cent. humidity is being carried. The carrying of these humidities on hot days makes it a good deal more pleasant for the workers than the dry, hot, natural conditions.

In addition to the effect upon the human being, the question of the elimination of dust and regulating humidity is of the utmost importance in many industries. In the manufacture of bread, capsules, chemicals, and I might mention a dozen others, it is almost imperative.

I will show you a few pictures illustrating some of the different buildings which have been equipped with cooling apparatus similar to those I have described.

Fig. 1. In New York, we consider this the last word in the Department Store—the new Lord & Taylor Building, located at 34th Street and 5th Avenue, in which the first floor has been equipped with an apparatus for cooling by evaporation. We put into that floor something like 100,000 cubic feet of air per

FIG. 2.

minute, and one day last summer I happened to step inside the store, just to satisfy my curiosity as to what the conditions were. I was standing there about two minutes, and during those two minutes I heard two remarks of how pleasant it was to do shopping in that store. One lady said, "I am always going to do my shopping here; it is so pleasant on hot days." It was not an exceptionally hot day. It was 82° outside when I went in the store, but inside the building it was down to 73° and it felt cool and invigorating to any person coming in from the street.

Fig. 2. I spoke to you about a textile mill. This is a cotton mill at Danville, Va. The mill on the right had a temperature of 111°, while the one to the left was 77°.

Fig. 3 shows the Main Mill and the humidifier and a fan blowing the air up through flues on each side of the building. The air comes in through fifteen of those risers.

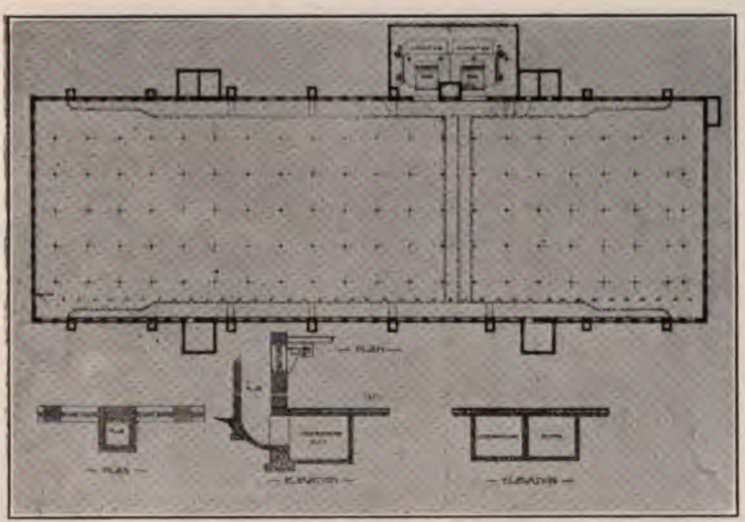

FIG. 3.

Fig. 4 shows the interior of the mill where the air was coming in. The heating coils have been placed at the different outlets, which enables the air to be heated as called for, independently of

FIG. 4.

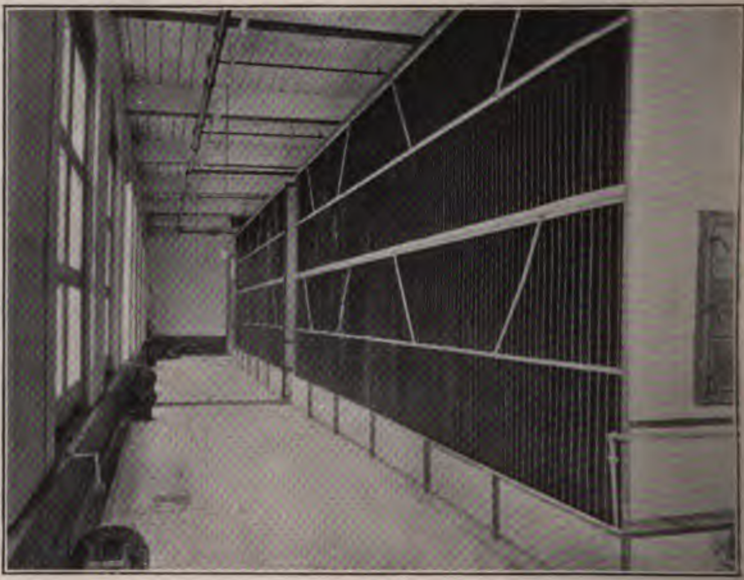

FIG. 5.

FIG. 6.

any other floor, and allows us to cool this room while we may be heating another room. In textile mills there is a great deal of heat generated due to the immense amount of power used in the mill. Take an ordinary spinning room; no heat is required in winter when the machinery is in operation, and the problem is to keep such a room cool. This arrangement enables us to cool any one room while we may be heating another.

Fig. 5. shows the humidifiers located in the basement, and these two machines are 30 feet wide each, 17 feet high, and 10 feet long. These units are operated on ball bearings and may be opened or closed as required.

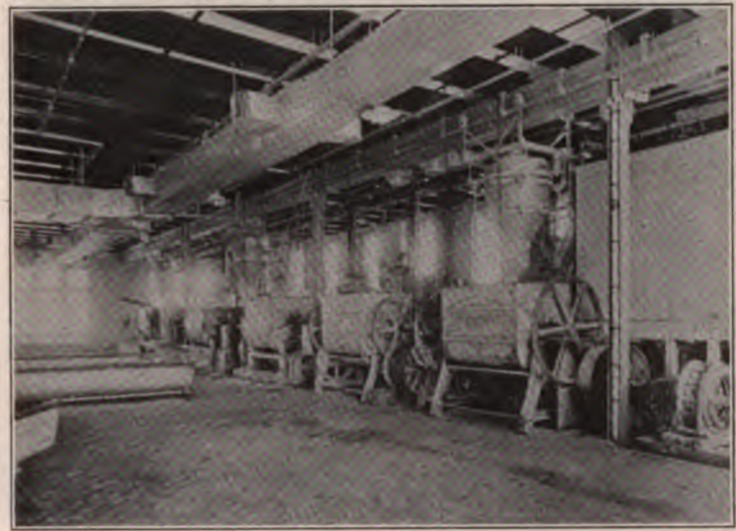

Fig. 7.

At twelve different openings here (Fig. 6) we have risers running through to the first floor. The basement is used as a stock room, and the machinery is on the floor above. A test was made at that plant not very long ago, and it showed less than three per cent. variation throughout the entire building.

In addition to many other plants, such as I have shown you —that is, in addition to textile mills, the question of humidity is of greatest importance; one of them is in bakeries. Four years ago there was not a bakery in the United States that was equipped for conditioning. Today there are thirty odd bakeries equipped

for controlling the humidity in their dough rooms. The germination of the yeast in the dough requires a certain temperature. In maintaining that humidity, if the temperature is not also controlled you will get a case-hardening on the outside of the dough which will prevent the gases generated in the rising process from being given off, and the time taken for the dough to rise will vary greatly with the weather. Previous to this control of temperature and humidity, the time for dough to rise would vary anywhere from three to five hours, depending upon atmospheric conditions. That

Fig. 8.

means that a man who is running his plant in the ordinary way will have his men standing around a couple of hours longer every day than need be, waiting for the dough to rise. On a business basis figured on the continuous operation of a bakery, it gives about fifteen loaves more bread per barrel of flour and makes a whiter and better bread than is procured where humidification and temperatures are not automatically controlled. This picture (Fig. 7) shows the bakery of the Gordon-Pagel Company in Detroit, where the air is brought in through this duct, and these are the troughs (ind.) where the dough is placed to rise.

Hard candies require low temperatures and low humidities for proper drying. For chocolates, humidity is not of such great importance, but low temperatures must be provided in order to congeal chocolate. Take macaroni. If macaroni were to dry too quickly, it would break all to pieces when the housewife gets it, and if it is dried too slowly, it is liable to mold, and so it is necessary that it be dried under humidity-controlled conditions.

The George Close Company Factory, Cambridge, Mass. (Fig. 8), where the air supply is brought in overhead. In this room the

Fig. 9.

temperature is maintained at about 60°, and the humidity at about 50 per cent., which is maintained the year round.

In printing establishments which do multicolor or lithographic work, the control of the humidity is absolutely necessary if they are going to turn out a high grade work and do it continuously. In most of the large multicolor plants a certain job may be a month under way, or in some cases I have known as much as two months to elapse between the time the first color was put on the paper and the last color. These plants are printing millions of copies of the same thing, and now that the temperatures

and humidity conditions are maintained constantly uniform, they get uniform results from their color plates.

Fig. 9 shows the plant of the Dittman Color Printing Company in New York, which is equipped for maintaining a constant temperature and humidity the year round. During September, 1913, there was not a multicolor printing firm in New York that was operating for one week, excepting this plant. This plant not only ran ten hours per day, but they put on three shifts per day during this very humid week and took work from other concerns that

FIG. 10.

were under penalty contracts. Mr. Dittman told me they never did better work than they did that week.

In the matter of high finish papers, where the paper is passed through hot rollers, if the paper is too dry it crinkles in the center, and if it is too wet it does the same thing on the edges; therefore the humidity and temperature should be controlled.

Fig. 10 shows the West Virginia Pulp and Paper Company's plant at Piedmont, W. Va. The paper is exposed in this room to a given humidity, and when it goes to the calenders it will give the best results. In what is known as "loft-dried" writing papers the con-

trol of humidity is absolutely essential for the best quality of paper.

The Plant of the American Tobacco Company in Virginia. Fig. 11 shows the stemming room where the stems are removed from the tobacco leaves. Anyone of you who has been in one of these rooms can appreciate what it means to take a picture there. In an ordinary room the dust is so thick you cannot see the third or fourth girl away from you. The girls usually work with sponges or handkerchiefs over their noses, and the

FIG. 11.

elimination of dust is accomplished by furnishing humidified air to this room. The machines are so constructed that it is practically impossible to remove all the dust, but the mere fact of holding a high humidity practically eliminates the dust from the room, so much so that these machines were stopped and the picture taken immediately upon being stopped, and you will notice we have made as clear a picture as any we have seen. The dust which is formed absorbs the moisture and falls to the floor.

CHAIRMAN.—Do you mean when you say "moist conditions" conditions which are uncomfortable?

A. No, but we get a much higher humidity than would ordinarily be demanded.

In the manufacture of bathtubs the control of humidity is very essential. Some two or three years ago I was visited by a chemist from one of the big Trenton potteries who were making solid porcelain tubs, and he said he was convinced that about half of their losses in the firing of their tubs was due not to troubles in the kiln, but because the core had been impoperly dried before it went to the kiln. I looked over the plant and put in an apparatus to

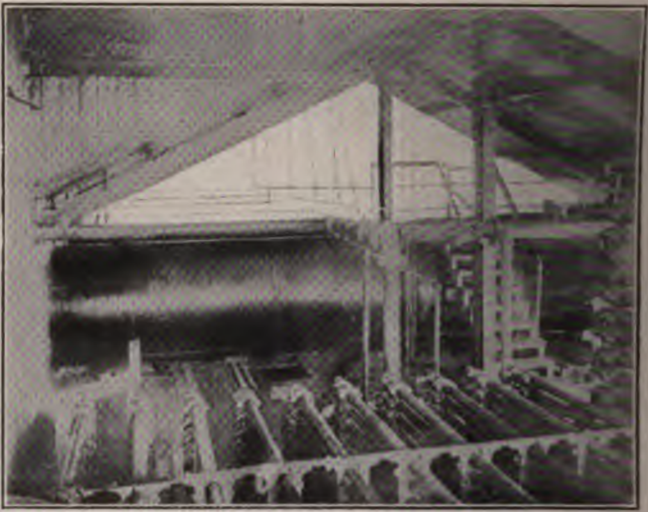

Fig. 12.

regulate the drying. We started out with very high humidities the first few weeks, and where it had previously taken about nine weeks to dry his wares, we began by drying in three weeks. We dried at very much higher temperatures than they thought possible, and they thought we would ruin everything, but after that ware was fired in the kiln they got 55 per cent. out of it. Instead of 25 per cent. of the first quality tubs, they are now getting 60 per cent.

Fig. 12. In the manufacture of pig iron in blast furnaces, Mr. James Gailey, formerly Vice President of the United States Steel Company, discovered a few years ago the reason for less coke

being required in a blast furnace during the winter than in summer; it was due to the fact that there was less moisture delivered to the furnace by the blowing engines, and he took out some basic patents on the process of delivering to the furnace a de-humidified air. The production of the furnace has increased something like ten per cent., and the coke consumption has decreased about ten per cent. and a more uniform and better grade of iron is produced.

When we started into business a few years ago, the last place we expected to be putting in a humidifying apparatus was

Fig. 13.

a machine shop; but we have had the pleasure of equipping machine shops for the purpose of cooling the shop and making it much more pleasant for the employees. Fig. 13. is a photo of one end of the shop of the Ford Motor Company in Detroit, where the entire shop is equipped with apparatus for cooling by evaporation.

We equipped the office building of the Company with this type of apparatus, and Mr. Ford observed that the temperature in his office was something like 15° below that of the outside, and he said that anything that was good enough for his office was good enough for his machine shop, and he sent for one of our engineers to figure

Fig. 17.

Fig. 17. This should be interesting to you people here in Philadelphia. The clear bottle showing a sample of water which you are using in the air washer. The jar to the left is filled with part

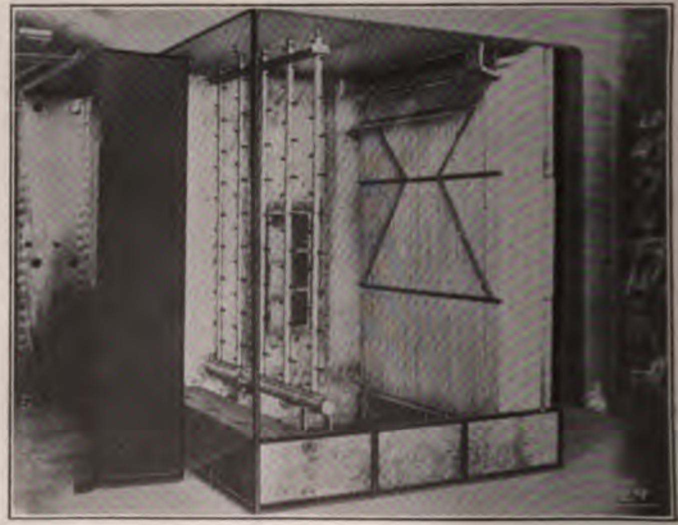

Fig. 18.

of the sweepings from the inlet where the air was taken into the building by the ventilating apparatus and in the third jar in the middle is a sample of the dirt that was taken out of the air washer. The air supply to the ventilating apparatus is taken from near the entrance of a garage. Of this last sample it was discovered that there was a space in the jar about $\frac{3}{4}''$ that seemed to be lubricating oil, and above that was what seemed to be dirty gasoline, and when a match was applied to it, it actually burned, showing that we were actually condensing the fumes from these automobiles and removing the gasoline and oil vapors.

I have simply shown you some of the plants in which air washing and humidifying have been applied. I will now show you a few slides illustrating the machines that are used in this work.

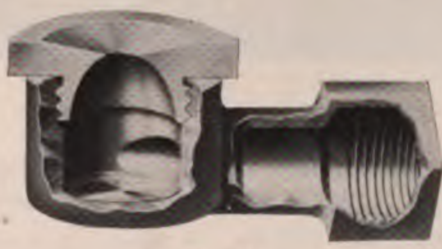

Fig. 19.

These same machines, I might state, with certain modifications, are used for air washing, humidifying, and for de-humidifying.

Fig. 18 shows the machine where the air is drawn through. A centrifugal pump takes the water out of the washer and passes it back to the sprays.

The water comes in from the pump located on the other side of the washer, into the header, up through the standpipe, and through these small nozzles. It then passes through an eliminator used for separating the water and air, and the air comes out clean without any entrained water. In addition to this set of nozzles at the inlet of the machine, on this type there is a second set of nozzles spraying down on the eliminators to keep the surface wet.

Fig. 19 shows nozzle used. The water comes into this chamber here which gives it a whirling motion, and as it approaches this cone-shaped orifice the revolutions are accelerated so it breaks into a very fine spray which will be seen better in the next slide.

Fig. 20.

Fig. 20. Showing the air going through in this direction (ind.). This is from an untouched photograph taken through the door by flashlight behind the spray.

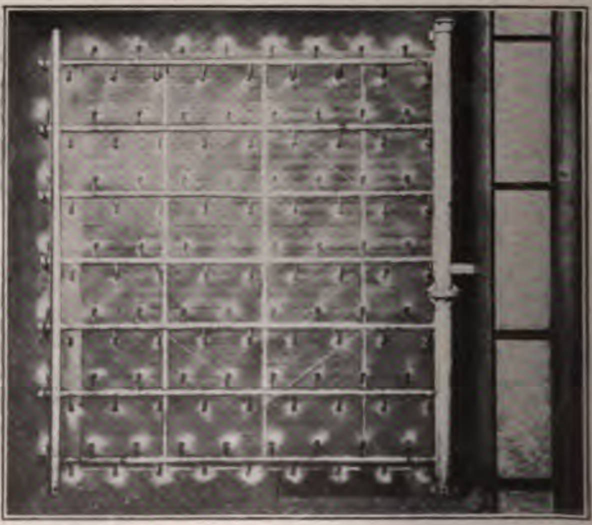

Fig. 21.

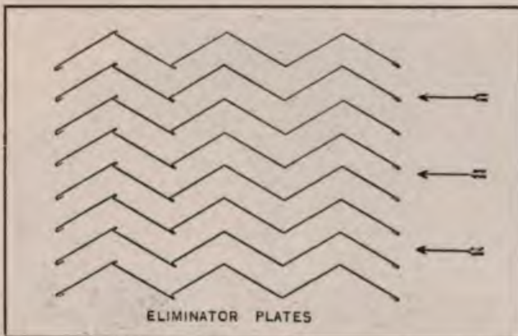

Fig. 22.

Fig. 21. This is looking at the inlet, showing the distribution of the nozzles, with them in operation. Each one of these sprays comes out in cone-shape and laps over the next one, so that there is no place which is not thoroughly covered with the spray. It is impossible for the air to pass through without coming in contact with the spray.

The eliminators (Fig. 22) are of simple construction; of different types, but all give the centrifugal action which throws the particles of dirt and water out against the surfaces. Here you see provision is made for keeping four corrugations wet all the time. These last two are sufficient to remove all the entrainment. The resistance to the air flow in the washer is largely due to the eliminator, and to the angle of deflection of the air. You can

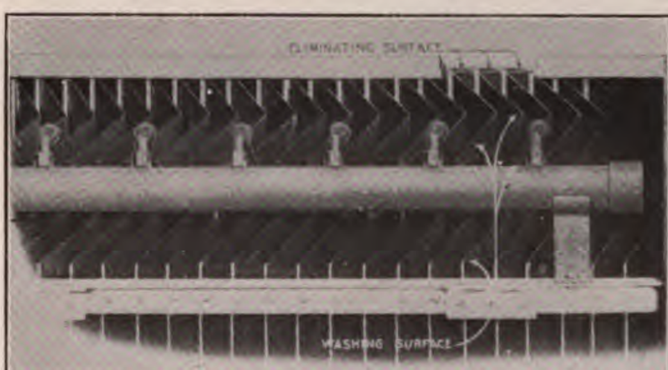

Fig. 23.

FIG. 24.

take this amount of surface and put it up in parallel shapes and you could not measure the resistance on the two sides of the eliminator. The greater this angle of the baffling, the less is the resistance produced.

Fig. 23 shows the top of the same eliminator.

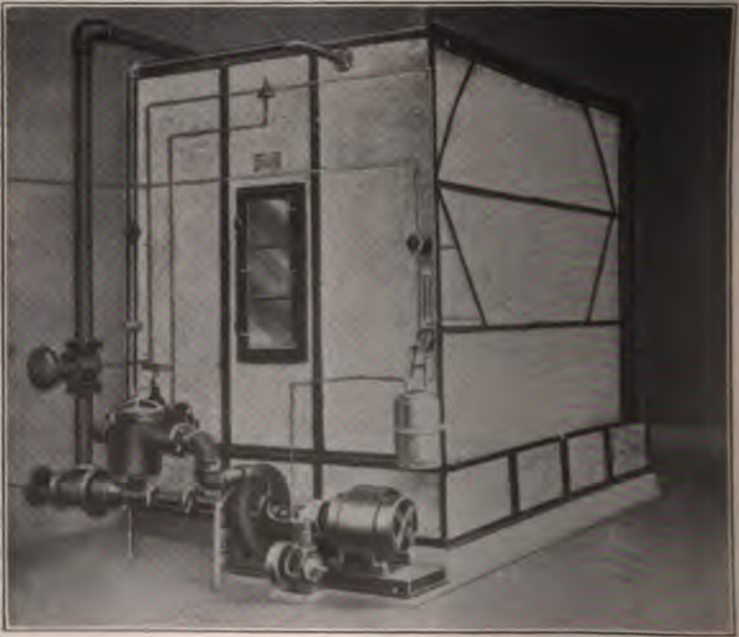

FIG. 25.

Fig. 24 shows the settling tank under the washer. The object in showing this picture is to emphasize the necessity of filtering the water. There have been two schools of washer designers, you might say. One has made use of a self-cleaning nozzle. After the dirt has gotten into the nozzle, an attempt is made to have some automatic means of releasing the nozzle. The others have attempted to eliminate the necessity for the self-cleaning automatic nozzle. All the water that is used here must pass

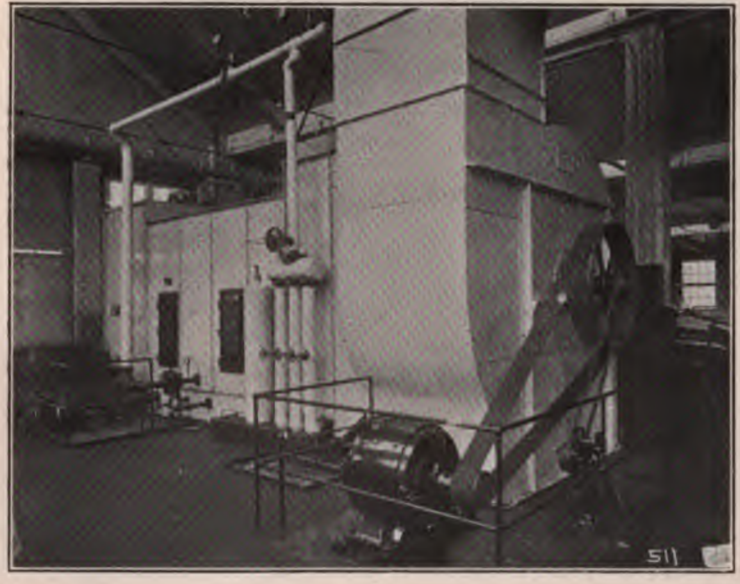

FIG. 26.

through a fine screen to the suction pipe, out beyond that screen, to the centrifugal pump from which it is forced back to the sprays.

Fig. 25 shows the method used for controlling the amount of moisture carried per cubic foot of air. In any washer that is using a heated spray you will get saturation. When you supply heat, you always get saturation and you know the amount of water vapor carried by air when it is saturated is dependent upon its temperature. So it is evident that if you control the temperature of saturation, you necessarily control the amount of moisture. All the excess water has been removed by the elimin-

ators, and we simply maintain a constant temperature of the air leaving the washer. A thermostat is placed in the chamber past the eliminator which controls the steam valve. There is a pressure of three to five pounds of steam which raises the air temperature and saturates it at the same time, so that the air leaving the washer is being controlled and the humidity is fixed. This is a simple arrangement, but still one that is positive and accurate.

Fig. 26 shows an installation in the plant of the John B. Stetson Company, in the weave room, where they weave silk bands for the hats.

Fig. 27.

Fig. 27 shows another view of the same apparatus showing the ducts which come out overhead. The method of distributing the air is one that varies a great deal, depending upon the local conditions where the application is made.

In the control of relative humidity we have a problem which is none too simple. The measuring of the humidity is done ordinarily by wet and dry bulb thermometers. The wet bulb has a wicking which is kept wet and shows a lower temperature than

the dry bulb owing to the evaporation. By tables we have, we are able to determine the relative humidity.

Fig. 28 shows the Carrier Differential Hygrostat which makes use of the wet and dry bulb principle for humidity control.

The relative humidity can be controlled by that instrument between one and two per cent. Ordinarily, in removal work, such refinement is hardly necessary; where humidity is maintained within four or five per cent., it is close enough.

Fig. 28.

In de-humidifying, as I stated, practically the same apparatus is used, with a number of details changed. In the de-humidifying we use cold water, or water that is said to have been artificially cooled. Where artesian wells are not available the water is cooled by refrigeration. The air is passed from the upper part of this machine, through the sprays of cold water, and the moisture is condensed out on exactly the same principle as a barometric condenser, only that you do the work at atmospheric pressure instead of at a vacuum pressure. The water which falls into this upper tank passes through and overflows into the troughs below. The trough is simply used to distribute the water which

trickles over brine cooling coils. The water is then taken back to the centrifugal pump and completes a cycle. The control is automatic just as in the other apparatus, and the humidity is controlled. The thermostat is placed here and operates this diaphragm valve so that the water is taken from the tank which has not been cooled, and not from the lower tank where the water has been cooled.

DISCUSSION

Dr. Henry Leffmann.—I am very much interested in this demonstration, of course, like all the other members, and I have experienced the troubles of unequal regulation of temperature and humidity in buildings, in this part of the world as well as on the other side. We have such a terrific climate that we suffer constantly, but there is no doubt but what this work is a most valuable contribution to the solution of a great problem of modern industry, the extensive factory development, the indoor work, and will deal with very many sources of discomfort as well as disease. It is, of course, well known to all who have had anything to do with manufacturing conditions that the diseases produced by the industries are in themselves subjects of very great importance. It is astonishing to see the number of cases of ill health from industries now in operation. I was appalled in reading recently a review of a book in one of the scientific journals on industrial diseases, the long list of diseases and injuries, internal affections and diseases caused by internal conditions in factories, and, of course, I have seen in my own experience the result of such conditions. This work is along one of the most important lines, for the purpose of preventing such conditions to develop, or the introduction of air in a polluted condition into these factories, both as regards moisture and as regards its temperature, and I feel that it is worth the attention of every-one who is interested either from the point of view of factory construction, or operation, or even from the point of view of the general question of sanitation and hygiene. Many of our members know that in the last few years there has been considerable upsetting of many of the old ideas in regard to badly ventilated offices. As to the introduction of carbon dioxide and the introduction of bacteria being the cause of disease in badly ventilated rooms, many of us are inclined to believe that it is due to the increase of moisture and heat and the odors. This whole question is one of the introduction of actual disease producing germs into the air. We circulate the air that comes in, and it may be more or less infectious, and proper ventilation is important for carrying off these germs. The time is coming when the man who has a cough or a cold will be quarantined.

In large factories the regulation of temperature and humidity is certainly of the highest importance, and from the mere point of view of greater efficiency of the factory conditions, will help in its adoption. The pocket nerve is after all a very important one, and when it can be shown that the return from labor is increased by these conditions, we will have them very much extended.

Mr. John Cassell.—For the past three years every new public school erected in this city has been equipped with an air conditioning plant. From two to four

old school buildings are remodeled each year, and fitted with a similar apparatus.

We have found air conditioning of very great value, as the air problem in the public schools is one of the worst we have to contend with.

We have taken up the subject of reducing the dust content and find the air washing apparatus has reduced air troubles 80 per cent.

I was in Meadville this week and met the Superintendent of Schools there, who has lately come from the West to take charge. He had improved the buildings and was insistent upon having air washers introduced, and when confronted with the difficulty and cost of installation, said, "Any old thing, I don't care what, so I can get humidity into the schoolroom air."

The relative degree in temperature to the per cent. of humidity must be taken into consideration, to obtain personal comfort in the classroom, as a high temperature and a high per cent. of humidity will produce the condition of a humid summer day and create a sluggish effect on the occupants.

I do not know the exact temperature and per cent. of humidity required to produce ideal conditions, but would suggest a temperature of 65° and about 50 per cent. humidity.

Perhaps some of the gentlemen who have had more experience than I can add something along this line.

Mr. Wm. Copeland Furber.—Early this summer, while Elbert Hubbard was attending a convention in Atlantic City, he praised its virtues and said that "Atlantic City was 'long' on air and air of the best and purest kind and this was one of its greatest attractions." He illustrated his appreciation of fresh air by saying, "A man can go forty days without food and three or four days without water, but he could not get along over two or three minutes without air," and this expression made a great impression on my mind as I have always advocated ventilation and air washing.

In the new building laws now being discussed for the State of Pennsylvania there will be a provision requiring all auditoriums and places of assembly to be ventilated according to the same specifications that now apply to school buildings: viz., 30 cu. ft. of air per minute per person. I think this is a very necessary and desirable provision. At present we have no laws governing the ventilation of our buildings and public places of assembly.

It is sometimes surprising to discover what great opposition there is to the introduction of ventilating apparatus in buildings where the public assemble in numbers. I have had many arguments on this subject in which very extraordinary ideas regarding ventilation are brought forward.

Some of you have probably heard the story of the Irish servant girl who shut herself in a tight closet during a thunder storm, and in complaining of her discomfort under the circumstances said, "The only 'vintilation' I had was me own breath." It is doubtless true that at present many places of public assembly have no other means of ventilation than that described by this Irish girl.

The argument that I use where the necessity of ventilation is questioned is that "You would not drink dirty water or wash your hands and face in water that some one else had washed in, but you are quite willing to breathe air that has passed through someone's else nose and lungs." This argument generally convinces the unthinking.

There have been a number of arguments brought forward in the last few years attempting to prove that fresh air is not a necessity, that the discomfort arising in crowded assemblies is due to the lack of circulation of the air and not to its impurities. If no other facts were available to refute this argument, I think it could be readily proven untrue by noting the marked improvement that occurs in health where pure fresh outdoor air has such a tonic effect on people whose health is below par. The approximation of the best outdoor conditions is what we should strive for in cleansing and furnishing fresh air to our buildings.

Mr. P. A. Maignen.—The success of cleaning the atmosphere in the buildings in which men and women are employed, as has been shown to us this evening, is very gratifying. It makes not only for economy, but also for the comfort of the workers; they produce more and what they do is better done. Taking away the impurities of the air is very much better than stirring them up from the floors to the ceiling. When we enter a crowded room, with overhead fans, we feel at once almost choked up by the dust. It were better that these fans had never been invented.

Have you ever stopped to consider the potentiality for evil of dust? If not, let us do so for a moment. Take a handful of the dirt from one of the pails shown on the screen. Put it in a jar full of clear water and let it alone for a few days in an ordinary room. Then place on a slide a drop of the "infusion," look at it through the microscope with a low power (about 100 diameters) and you will see what was originally called "infusoria" or animalcules, now going by the name of micro-organisms, microbes, or bacteria. Among these micro-organisms are to be found bacilli (rod-like), micrococci (grain-like), vibrios (quivering), spirilli (moving like a serpent), protozoa (animal-like); among these are the paramecia, the amebae, and the rotifer. Expert bacteriologists, by using a higher power and staining the preparations, can show you many other kinds of germs which are generally more dangerous (because they are smaller and can penetrate deeper in the tissues.

Why all these germs? What is their destiny? Each and every one of them has a purpose though we may not understand it. The purpose is not to pester us, it is rather to help us by decomposing dead organic matter—material which has formed part of a living body, or a whole living body which has ceased to live—and transform it into inorganic substances suitable for the support of new plant life, which in turn is to feed animals and men. These germs can do us no harm unless we open the gates wide for them. This we do when a breach is made in our skin or mucous membrane, or when we allow excessive watery excretions on the skin or on the mucous membrane.

It has been said that dust was the right thing in the wrong place. It is the right thing if put on the fields as a fertilizer, but it is a very wrong thing if we eat it, drink it, or breathe it. Remove it from the room in which you work or live by opening the windows when you are not in the room, or by installing some improved system of ventilation, such as has been shown here tonight.

Something has been said about the influence of germ life on the health of people. A few words on the subject may not be out of place.

Among the disorders traceable to dust may be mentioned Tetanus and Blood Poisoning. The germs which produce these disorders are to be found in the

dust of the air, but more particularly on the surface of the body or on the ground, or on any neglected objects such as rusty nails. The danger of their introduction in the living tissues is proportionate to their penetration therein. A proper disinfection as soon as the injury is inflicted may avoid the danger.

There is a much more common form of injury due to dust which is very little heeded because it is not understood although it is extremely common. I mean that form of abnormality which is termed a "cold." We say he has "only a cold"; it is a "bad cold," and "awful cold"; but what is a "cold"?

In olden times a "Cold" was described as a "morbid affection induced by cold." Later it was spoken of as Catarrh (to flow), or as "a discharge of fluid from a mucous membrane." Still later it was represented as an "inflammation of the mucous membrane." Lately we have been told that cold and wet had nothing to do with "Colds" and that "Colds" were only the result of bacterial infection. The truth is that cold, draughts, and damp have something to do with "Colds," and so have the micro-organisms also.

The first factor in Colds is an excessive secretion of mucus, and the second the proliferation of germs in the "mucus." Over exertion, particularly in warm weather, produces external perspiration or sweating; the excretion from the pores of the skin is a salty watery liquid. Sudden or protracted exposure to cold or damp produces internal transpiration, and the material excreted from the mucous membrane is albuminous or mucilaginous. It is well known that if the skin is not kept perfectly clean perspiration gives a bad odor. Odor is the product and evidence of bacterial activity and the germs live and thrive on the organic fluid on the skin. Likewise the excess of mucus on the mucous membrane of the Respiratory Tract constitutes what is sometimes called the catarrhal condition and goes also by various other names.

In this disease it is generally the large germs or protozoa that do the work. They feed on the product of the internal perspiration. If there were no more mucus than is necessary for the lubrication of the membrane the germs could not multiply; they would be kept at bay by the vital principle; but when the membrane is more or less clogged up with an excess of the mucus, the function of the membrane is interfered with and the parasites have it all their own way. The nose is a kind of garbage can, if it is not kept clean it becomes a source of danger.

Let us return to our microscope and place on the slide a drop of the matter discharged from the nose or throat when we have a "Cold", Catarrh, or the like. We see "things." If the discharge is blackish we see the amebae (large opaque round cells without motion) spread on a field of filamentous matter or placque (strawberry patch). It is this filamentous mass which gives tenacity to the mucus. It is threadlike or ropelike just as the scum of stagnant water. It adheres firmly to the mucous membrane as moss adheres to stones.

When the discharge is yellow, as, for instance, when a "Cold" breaks or becomes loose, the organisms to be seen are smaller, they resemble "pus" cells, and, like pus cells, they are loose and not entangled in a net-like field as is the case when the "Cold" has developed into Catarrh. In the latter case they are also strewn over filamentous patches and the "matter" is tight. You "hem" and "hawk" without productiveness. The "matter" drops from the nose into the throat, and from the throat into the stomach or through the windpipe into

the bronchial tubes. At this time the "Cold" has become a generalized Catarrh or something worse. The inflammation is the result of Catarrh and not its cause. The substance of "Colds" and Catarrh is the weed-like parasitical growth on the mucous membrane referred to above which can be compared to locusts and weeds on fields. The true enemy, therefore, is the dust that floats in the air, the germs that are in the dust, and the internal perspiration which takes place when we are exposed to draughts of cold air or dampness.

If you wish to keep free from "Colds," avoid dust first, and second remove it from your nose when it gets there.

The life of germs is not eternal, they die as we die. They are reproduced as plants and animals are reproduced, sometimes by budding and sometimes by eggs. Their food and environment must be appropriate. When in the air they do not grow though they do not die. When in a moist environment they are incubated like seed in the field or fish-eggs in the water. They die because they have no more food or because they have fouled their nest.

An example of this phenomenon is to be found in the behavior of water on board the old sailing ships. It is of common record that there is not a mariner sailing from a given port who will not say that the water of such or such a port, as for instance, the water from the Thames in olden times, was the best water in the world. The fact is that a few weeks out of sea makes all the difference. At first the water ferments or putrifies, all the organic matter is decomposed by the germs and a few weeks later the water is practically pure and the germs and their product are down at the bottom of the vessel "dead ones." You can make the same experiment as I made in London years ago with water taken from a whale pond at one of the Exhibitions. The water at first is offensive, has an odor, and is cloudy, but as time goes on you can see it becoming perfectly clear and odorless and actually fit to drink. All the germs and their food have lived their life and are now as inert matter and, therefore, incapable of doing any harm.

Different kinds of germs succeed one another in their work of decomposition of organic matter as the alcoholic ferment is succeeded by the acetic ferment in the making of wine and vinegar, or as the reapers are followed by the gleaners in the wheat fields. The best way to deal with germs is not to let them grow and multiply in places difficult of access, and to remove them when they are still at the door. Remove them from your rooms, remove them from your nose and lungs, and you will keep healthy. The presence of dust or dirt or catarrhal matter on the mucous membrane is like rust on steel, fungi on wood, scale in boilers, etc.

What has been said about Colds and Catarrh applies with equal force to the peculiar form of Catarrhal condition known as Hay Fever, Rose Cold, and Bronchial Asthma, whose "germ" the speaker has had the good fortune to identify. It is a protozoan, a very large animal-like organism which has originally entered the respiratory tract with the spring or summer dust and established its quarters in the air passages.

If you have Hay Fever or Asthma you can see, under the microscope, in the discharge, the peculiar organisms referred to, and which, when fully developed, looks like a miniature hippopotamus with the legs of a centipede. This can also be guarded against by keeping the Respiratory Tract thoroughly clean in the

dusty months of the year, and also be cleaning out the nose, throat, and lungs by appropriate methods all the year round as a prophylactic measure.

A certain degree of humidity in the air may be a good thing, but, as Mr. Cassell said, too much of it may be bad. You do not hear of Catarrh or Hay Fever in high altitudes, whilst in low places like Philadelphia or the Lake region, almost every-one has Catarrh and many have Hay Fever. It is well known that Hay Fever sufferers have relief when they quit the lowlands and go up into the mountains, and that the trouble returns as soon as they go away from the mountains. Too much moisture, therefore, should be avoided.

Mr. E. M. Nichols.—You spoke of temperatures of approximately 100 on the outside and 76 on the inside. Was there any question of discomfort, no matter what the humidity was?

Mr. Lyle.—A great many people seem to think that if you have a high humidity, it is going to be uncomfortable, regardless of conditions. Mr. Cassell said something about that also, that with a given temperature you want a given humidity, and you must not go above that. You are able only to a certain extent to know absolutely. It is true that if we had some of those conditions that some of the writers on this subject speak of—that is, 90 per cent. temperature and 90 per cent. humidity, we would have uncomfortable conditions. Taking general conditions, where we are heating a house, I agree that we do not want excessive humidities, but I believe, in fact I know, in summer you can carry high humidities and be comfortable, due to the lower temperature produced by the high humidity, more comfortable in fact than you would be with a reverse condition of high temperature and low humidity.

I will just give you a few figures. I know of a silk mill where, with an outside temperature of 93° and 40 per cent. humidity, the inside of the building was maintained at 82° temperature and 76 per cent. humidity. Most people will contend that 76 per cent. humidity was impossible, and that it would be bad. It would be if you went from this room into 82° temperature and 76 per cent. humidity, but with the conditions quoted it is perfectly comfortable.

There is a committee in New York now trying to determine what are the real things to be considered in ventilation, and they are spending $50,000 on the problem. They have found that you are affected by the outside temperature even though you are not exposed to the outside temperature at all. They have found that the body temperature of 98° will vary with the outside atmospheric conditions. They put a man into a room absolutely sealed and made air-tight, with the door locked and treble sash on the windows. They gave him a certain air supply and held the temperature and humidity constant, and found that the body temperature would vary with the outside air conditions. So that there is something else than the mere temperature to be considered. A day that will be fine and moist and pleasant during extremely hot weather will be most unbearable in extremely cold weather.

I imagine that I have answered your question, that in order to get this cooling of the building it is necessary to do it by the evaporation of the water. We drop a temperature from 15 to 24 degrees by the evaporation of water. For every grain of moisture per cubic foot taken up we drop the temperature of the air 8.25° and we give a more pleasing condition.

Mr. John C. Trautwine, Jr.—Mr. Lyle's paper has a sociological as well as a technical significance. It sounds the knell of the small potato.

Air conditioning, Mr. Lyle tells us, gives a competitive advantage to the manufacturing establishment which adopts it.

But the small establishment cannot afford to adopt it; and hence the small establishment is handicaped in the competitive war of extermination.

Air conditioning thus constitutes one more nail in the coffin of small business, which is rapidly and inevitably giving way to big business; while this last, in turn, is just as inevitably giving way to real business, i. e., to the public ownership and public operation of all business—to the immeasurable advantage of all.

In the air-drying apparatus described by Mr. Lyle, the air, in turning corners, throws the heavier moisture outward by centrifugal force.

This reminds me of a water-purifying device, designed, some twenty years ago, by Gathmann, of gun fame, if I remember rightly. The apparatus consisted simply of a large stationary cylindrical tank. The raw water was led into this tank in a tangential direction, at its periphery, and, after describing one or two turns around its vertical axis, was drawn off, purer (again tangentially, I think); for, owing, doubtless, to the lower specific gravity of the water-borne impurities as compared with that of the water itself, these impurities clustered, in a thin vertical pencil, about the axis of the cylindrical tank, and were drawn off at top and at bottom of the cylinder.

Mr. Cassell's discussion reminds me that my son finds the readings of the wet-bulb thermometer alone (irrespective of the temperature) a very satisfactory index of the comfort and discomfort experienced by the human body during warm weather; the body itself being in effect a wet-bulb thermometer; the perspiration corresponding to the water placed on the bulb, the skin to the cloth covering of the bulb, and the action of our nerves to the expansion and contraction of the mercury in the bulb.

Thus, with the termometer in the nineties but with low humidity and a good breeze the condition is relatively comfortable; but if, then, the humidity rises to a maximum (even though the thermometer meantime falls 10 or 15 degrees)-the wet bulb thermometer will rise, and the discomfort will increase correspond, ingly, in spite of the fall of the thermometer.

Mr. Lyle—Mention was made of the wet bulb temperature affecting the comfort of humanity. Dr. Leonard Hill was the first, I think, to discover that fact, and he has given it that the wet bulb thermometer is the one we want to consider and not the dry bulb at all. Personally, I do not agree with him. I only know that the wet bulb temperature is the actual measure of the total heat of the air, but from such observations as I have been able to make, and those that are associated with it, the indications are that it does not run in direct proportion to the wet bulb.

I did not intend to extend my talk very long, but there were one or two things I did not touch upon. One was the question of efficiency and the increase in production. Practically every one of these installations that I have shown you tonight, with the exception of the department store and the machine shop, have been installed with the idea of increasing the production. The first machine shop installation was made for the purpose of bettering the health, but the others have been installed because of the direct bearing of the installation on

the finer work being done by hand. In the textile mills they can spin or weave better under proper atmospheric conditions. Take cotton, for instance: with proper humidity every fibre is more pliable and better yarns are produced. And so on for bread and everything else. It is done for the purpose of increasing the production, from the standpoint of the material. Incidentally, there are better living conditions produced, and, as a consequence, better health.

Mention was made of starting up dust with electric fans. This is a little outside of what we are discussing, as we are most prominent in discussing questions of ventilation, and not the question of dust removal, although the control of the humidity conditions also, of course, has a bearing on the dust problem, and does keep it down. An electric fan does stir up the dust, but it brings a new filament of air to the body and makes living more pleasant.

A Member.—Do you use any chemical for removing moisture from the air?

Mr. Lyle.—Quicklime, calcium chloride, etc., have been used. The one scientific reason why it is objectionable is that immediately you absorb the moisture from the chemical you liberate the latent heat which raises the temperature of the air, and for most processes makes it entirely objectionable. Another thing is, as far as I know, there has been no economical method used or developed for the use of the chemical; you have to reclaim your chemical by getting your moisture out of it, and by the time you get through cleaning it, it has cost more than it is worth. These methods have not been used on a commercial scale.

A Member.—Do you consider it advisable to carry a certain number of degrees below outside temperature, or do you try to carry a uniform temperature throughout the year?

Mr. Lyle.—In such work as they are doing, you do not want a temperature below 75°. If it is going above that, you hold it just as low as the apparatus can be kept down. The New York Stock Exchange has a 300-ton ice machine in it. That was put in for the purpose of maintaining 75° in hot weather. When they put it in and got it started, they found that if the temperature of the Stock Exchange was more than ten degrees lower than the outside temperature, it was objectionable. For instance, if they had 75° inside and 85° outside, it was comfortable, but if they got more difference than that, the man coming in from the outside would feel a chilling effect. Take the mill proposition and hold the temperature lower than that, and you do not get as bad a condition.

A Member.—I would like to know what material is used in the elements, as regards withstanding corrosion.

Mr. Lyle.—That is a hard question to answer. We started out in 1906 by building our machines of ordinary galvanized steel. Since then we have made them of copper, of ingot iron, Toncan metal, some of tin, some of lead coated material; we have had some enameled; we have tried almost everything, and we seem to be about as far from the solution as when we started. The first machine we built is still in operation and does not show any corrosion except that it is black. The last time we had it inspected there was no rust or corrosion. On the other hand, we have had machines that have gone to pieces in three months. I have

seen machines, built by a competitor of copper, where I could stick my finger through the side of the washer. It all depends upon local conditions. In the Bankers' Trust Company of New York we put in a machine for cooling the banking room floors. Within a year certain parts of that machine were all apart. We jumped at the conclusion that the cause was electrolysis, but an analysis of the water showed 22 grains of free sulphuric acid. The water used is Croton water, which is alkaline, but after a few days' run it has sulphate in addition to the 22 grains of free sulphuric acid. This could not come out of the water so we concluded it must be taken out of the air. Just around the corner from the building was the Assay Office, and we were getting enough fumes from the assay office to give us this sulphuric acid in the air, and I do not know of what to tell you to build machines that will stand 22 grains of free sulphuric acid. We cured that case, however, in a simple way, by setting up float valves so that the water would go above the float and a certain amount go to waste; most people would not want to do that, but it is better to let a certain amount of water go to waste than ruin your machine, or they want to clean out the machine once or twice a week and put in fresh water all the time, or, if that is not feasible, make your machines out of galvanized American ingot iron. All rivet heads in our machines are soldered, and with ingot iron you have an iron that will not pit through. We have put steel in a place where galvanized American ingot iron gave way in four months. Black ingot iron coated with enamel has lasted for eight months without any trouble under a very bad condition.

Dr. Carl Hering.—You spoke of enamel; did you mean baked enamel?

Mr. Lyle.—No, it was self-hardened. I do not think baked enamel would be successful; for anything brittle would chip off, but being self-hardened any little bend in the shop would not crack it. In this machine in the Bankers' Trust Company we put in a new section of pipe; it was all put in brass with the exception of one piece covered with Bitumastic, and that has been in for about eighteen months. My point is that I do not know that there is any one metal which I can see is going to cure all ills. In one case they were getting water which upon being analyzed was found to be all right, but a second analysis showed they were getting sewerage.

Paper No. 1146

BITUMINOUS COALS; PREDETERMINATION OF THEIR CLINKERING ACTION BY LABORATORY TESTS

By F. C. HUBLEY

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The Clinkering of Bituminous Coals in Boiler Furnaces.

In order to promote efficiency of operation and reduce the cost of steam production to a minimum, it has become more or less of a practice in recent years for large steam users to purchase coal subject to certain specifications, which, though rigid in a sense, are made broad enough to permit of the use of the output of mines from a number of districts. In general, a standard fuel is specified in terms of proximate analysis, sulphur content, and heating value, a price per ton for this standard is agreed upon, and a bonus or penalty provided for grades of fuel above or below this standard. As a rule no particular mention is made of clinker-forming properties or, at best, a clause is inserted providing for the rejection of the fuel, provided steam pressure cannot be maintained under ordinary operating conditions.

The failure of most specifications to effectively regulate or provide limits for this property, a matter of as much, if not greater, importance than the heating value of the fuel, is in all probability due to the lack of a standard laboratory test for the determination of the clinkering tendency. It naturally follows that if such a test were devised, from the results of which it would be possible to indicate or predict the clinkering tendency of the fuel, an additional clause could be inserted in the usual form of specifications, which should protect the buyer from this trouble. With this end in view, it has been the idea of the writer to perfect and standardize a laboratory test which will more or less definitely indicate the clinkering properties of a coal, both as to temperature and nature,

and which will supplement the usual proximate analysis and B. T. U. determination, in the valuation of fuel for steam boiler use.

Considered briefly, the losses incurred by either the capacity or efficiency of the plant, due to clinker formation, may be enumerated as follows:

First. Unburned combustible in the flue gases resulting from the retardation and poor distribution of air throughout a fuel bed in which ash fusion has occurred.

Second. Unburned combustible in the refuse ashes, which, in good practice, with a non-clinkering coal, should be in the neighborhood of ten per cent. of the total refuse ashes, and which has in some extreme cases, while burning a badly clinkering coal, amounted to fifty per cent. of the weight of ashes removed, or approximately six per cent. of the total fuel fired.

Third. The item of labor in cleaning fires and upkeep of fire boxes will be materially affected by the amount and nature of clinker formed. A spongy porous clinker is easily broken up and removed, provided it can be reached, without any serious effect on the life of bars or lining; while a close hard clinker, although possibly formed at approximately the same fire box temperature, will tend to materially increase the upkeep costs of a boiler plant.

Fourth. In the case of high and frequent loads on a boiler plant, the difficult problem of smoke prevention becomes more complicated with a clinkering coal—especially with the high volatile bituminous coals of the middle west districts; and while no data is available as to the amount of the fuel loss appearing as unburned carbon in black smoke, its prevention is often a necessity in districts where an exacting smoke ordinance is enforced.

Fifth. Considering the effect on capacity, the labor of firing boilers with coal containing a low fusing ash is greatly increased at times of greatest steam demand, in order to quickly produce the required increase in rate of combustion. In the case of plants where the peak loads are high and frequent, this clinkering on the boiler grates may become very troublesome, in some cases resulting in a partial steam failure, although the plant has ample rated boiler capacity when burning a non-clinkering coal.

Basing an opinion on proximate analysis and heating value only, the selection of the cheaper fuel is a natural course for the purchasing department to take, if unguided by further information as to ash fusibility or clinkering tendency. For example:

Coal "A" contains 22 per cent. volatile matter, 6.5 per cent. ash, 1.40 per cent. sulphur, and 14,600 B. T. U. per pound. The ash fuses at 2,150° F. and the fuel cost $1.20 per ton at the mines. Coal "B" contains 16 per cent. volatile matter, 6.5 per cent. ash, 1.50 per cent. sulphur, and 14,750 B. T. U. per pound. The ash is highly infusible, melting at a temperature over 3000 F. and the fuel sells at the mines for $1.50 per ton. It is quite evident that the price difference between "A" and "B" is not entirely accounted for by heating value or ash content, in which case the selection must be made on a basis of ash fusibility, or other quality.

On account of the attractive price, Coal "A" was selected for part of the steam coal supply for a certain rolling mill. This mill rolled an average of 345 tons of finished material in a twelve-hour turn, requiring 1875 boiler horse-power to operate or approximately 34 tons of steam coal. The saving in a twelve-hour turn in cost of fuel "A" over fuel "B" for this mill would then be $10.20. A further consideration of this problem shows, however, that assuming a profit of $6.00 per ton on finished rolled material, a delay in this mill of 3.5 minutes in a twelve-hour turn (due to steam failure) will be sufficient to vitiate this saving of $10.20.

It was found necessary in the use of fuel "A" in this mill to decrease the time between fire cleaning from six hours to four hours in order to maintain steam pressure, in spite of which a number of steam failures were recorded varying in duration from five to thirty minutes.

From these considerations it would appear that, in addition to moisture, volatile matter, fixed carbon, ash, sulphur, and B. T. U. value of a fuel, it is necessary to know the fusing point of the ash, and the nature of the fusion, in order to have an accurate knowledge of a fuel; which data, in connection with some idea of the maximum required rate of combustion and its corresponding furnace temperature, can then be used in connection with expert design of a proposed boiler plant or the intelligent purchase of fuel for an old installation.

The ordinary conception of the term "fusing point" as applied to a compound, namely, a fixed temperature at which transition from a solid to a liquid state occurs, is misleading, and, we believe, inapplicable to most substances. The temperatures on the scale between which a compound changes from a rigid solid to a thin

liquid are in general widely separated, and in all instances the interval has a measurable range. Therefore, it readily follows, in the consideration of a complex mixture such as coal ash, that, although the term "fusing point" cannot be fixed or defined, the term "fusing range" is capable of precise definition and experimental determination.

The purpose of this paper is, if possible, to show: First, that by laboratory experiment the "fusing range" of a coal ash can be definitely determined; second, that there is always a point, capable of recognition, in the fusing range, which although not the fusing temperature in the ordinary sense, is, nevertheless, a stage past that of incipient fusion; third, that this point or temperature bears a direct relation to the clinkering temperature in a boiler furnace; fourth, that the nature of the clinker formed, whether porous and spongious or close and hard, has as much to do with detrimental effect on boiler operation as the question of temperature of formation. It should, therefore, be noted in the following discussion that where reference is made to "fusing point," it is intended to denote an arbitrary temperature in the fusing range, the recognition of which will be a requirement in the experimental determination of the fusing range of a coal ash.

An attempt will also be made to approach this subject from the analytic side, plotting fusing points against combinations of the ash constituents, in an endeavor to determine some definite relation or modulus, whereby the approximate fusing point can be fixed by a determination of two or more of the ash elements by chemical analysis.

Fusing Point of Ash by Cone Method

This test, which consists in the formation of a small test cone from the coal ash, and the subsequent determination of the fusing point of this cone in a furnace, by means of a pyrometer couple, may be described in detail as follows:

Preparation of Sample

A sample of approximately two pounds representing the coal is ground to 60-mesh and then burned down in small glazed dishes at a dull red heat, until all carbon is consumed. The resultant ash sample is then ground in a mortar to entirely pass a 60-mesh screen and thoroughly mixed.

Test Cone

The test cone is formed in a hard wood mould, similar to a split core box. The ash is ground with water and a binder in a mortar, until a stiff paste is formed. The cones are roughly formed by hand and forced into the mould which has been previously lined with glazed paper to prevent sticking, after which they are removed and, with the paper still adhering to them, baked in an oven at about 250° F. fo: ten minutes and then placed on wire gauze over a Bunsen flame to burn off the paper. This method will produce cones of uniform size and sharpness and of sufficient hardness to withstand handling. The cone is approximately two inches high with an extended base one inch in diameter.

Binder

Dextrine was found to be a satisfactory binder for this purpose, ten per cent. of which with the ash, on the addition of a little water, formed a paste which could be moulded successfully. More than ten per cent dextrine in the mixture has a tendency to distort the cones in baking, due to the liberation of volatile matter and less than this amount will not bind the mixture sufficiently. Dextrine used by the writer analyzed 94.42 per cent. volatile matter, 5.19 per cent. fixed carbon, and 0.39 per cent. ash. It was assumed from this analysis that a 10 per cent. mixture of this substance in an ash sample would have no appreciable effect, from a chemical viewpoint, on the fusing temperature.

Arrangement of Furnace

The fusion test is carried on in a Fletcher Crucible Furance, which is cylindrical in shape, 2¾″ diameter and 3½″ high, inside dimensions. With an ordinary blast lamp, using illuminating gas, fairly high temperatures—in the neighborhood of 2700° F.—may be obtained, although Blau Gas is a more satisfactory agent in this respect, the use of which will produce a temperature of 3000° F. with ease. Two extra holes are made in the side of the furnace near the top, one for observation and the other a vent for burnt gases. The cone is placed in an upright position on the furnace bottom and the burner pointed in at an angle to give the flame a whirling motion inside the furnace. The platinum-rhodium pyrometer couple, which is bare for about two inches of its length from the bead, dips into the furnace from the top and is held so that the bead is very close to the point of the cone.

Observations

The furnace is heated gradually until the cone begins to show signs of fusing, denoted by the sides losing sharp outline or by a swelling in the cone body. The furnace is then held at this temperature for three minutes, when the cone is removed and allowed to cool in the air. Other cones from the same ash sample are in turn given this test, the final temperature in each case being regulated to give a series at 25- or 50-degree intervals on either side of the temperature obtained in the preliminary test. A sufficient number of cones should be provided in order to completely explore the fusion range of the ash under test, or in order to obtain a series of cones from a temperature of no deformation to one at which the ash flows readily. From this cone series an arbitrary point may be recognized at which temperature complete fusion, in a sense, has occurred.

The following illustrations show results which may be obtained from this method of testing coal ash. In each case it has been the endeavor to get as complete and unbiased an opinion as possible from the boiler room, as to the behavior in the fire box of the coals represented. These criticisms, while difficult to obtain accurately, have in most instances agreed closely with results obtained by the writer in laboratory tests.

Test No. 4330 (Figure 1)

This coal, typical of the better grades from the Middle West fields, was mined at Grape Creek, Illinois, and consumed under Babcock & Wilcox boilers equipped with chain grate stokers, operating under approximately a constant load.

Analysis of the Coal

Volatile Matter %	36.18
Fixed Carbon %	48.38
Ash %	15.44
Sulphur %	1.459
B. T. U. per lb. of dry coal	11510

Analysis of the Ash

Silica % SiO_2	40.88
Alumina % Al_2O_3	19.27
Iron oxide % Fe_2O_3	14.85
Lime % CaO	10.94
Magnesia % MgO	0.47

Sulphuric Acid % SO_3	6.40
Color of ash	Light brown
Fusing point (cone method) F.	2370
Color and nature of fusion	Red-non-porous

Referring to the photograph of this cone series, Figure 1, where the shape and size, but unfortunately not the color of the resultant ash cones are shown, it will be observed that a thorough exploration of the fusion range of the ash under test is here obtained. Nos.

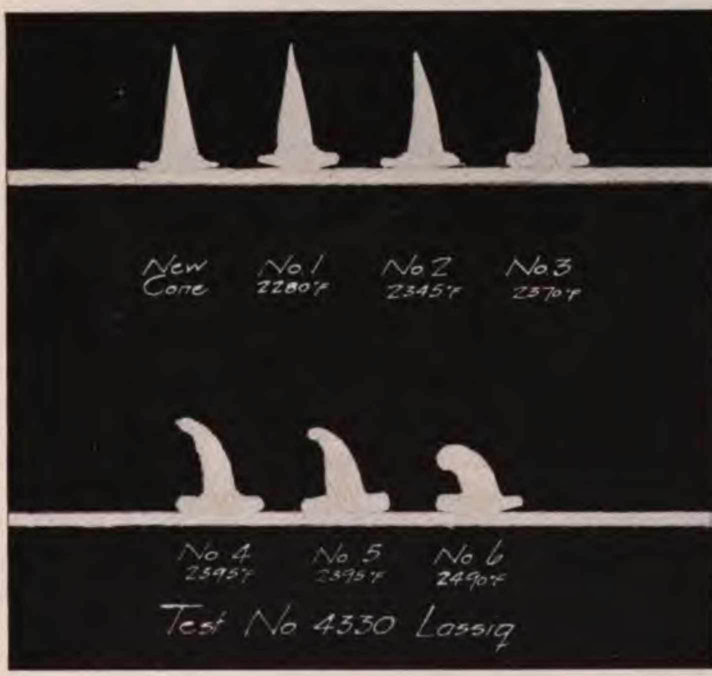

Fig. 1.

1 and 2, though slightly distorted, are light brown in color as in case of the original cone, while No. 3, in undergoing greater distortion, changes to a dark blue or purple. Nos. 4, 5, and 6 show more advanced stages in the fusion of this sample. Cone No. 3 has been selected as the point at which complete softening is under way.

Note the lack of increase in height or volume of the cones as the temperature is increased, and that a close hard clinker is ultimately formed.

Considerable information may also be obtained from the cone test in regard to the "stickiness" or viscosity of the ash at various temperatures, by noting the ease with which the cone may be removed from the furnace, after being subjected to a certain temperature for three minutes.

Cones Nos. 1 and 2 did not adhere to the furnace lining in the slightest degree, while No. 3 was firmly adhering and Nos. 4, 5, and 6 were only removed by a partial destruction of the furnace lining. In this latter case it seems fair to assume that a similar destructive effect will be obtained on the brickwork of the boiler fire box, when this coal is forced to a high furnace temperature.

It is probable that the ash from this coal, if subjected to a furnace temperature of 2370° F. or greater, will build up a close hard clinker, the removal of which from the boiler fire box cannot be effected without damage to both lining and grate bars. This temperature corresponds, in the writer's experience, to a load of 115 per cent. to 130 per cent. of boiler rating, although information as to the average boiler load, under which this coal was given a practical test, is unfortunately lacking. The criticism coming from the boiler room states:

"The coal has a clinkering tendency which does not interfere with the keeping up of steam. It clinkers with medium and forced loads on sides of furnace and against bridge wall, and it becomes necessary at times to use slice bars to break the clinker off."

Test No. 4849 (Figure 2)

The ash from this coal, although fusing at a lower temperature, is very similar in behavior to that under Test No. 4330, the resultant clinker being close and hard. The coal is mined in Illinois and has the following analysis:

Volatile Matter %	37.29
Fixed carbon %	47.28
Ash %	15.43
Sulphur %	1.738
B. T. U. per lb. of dry coal	11800
Fusing point of ash (cone test) F.	2150
Nature of clinker	Close-hard. Non-porous

Note the 30° F. intervals between the cones and the very gradual reduction in height which appears to be proportional to the in-

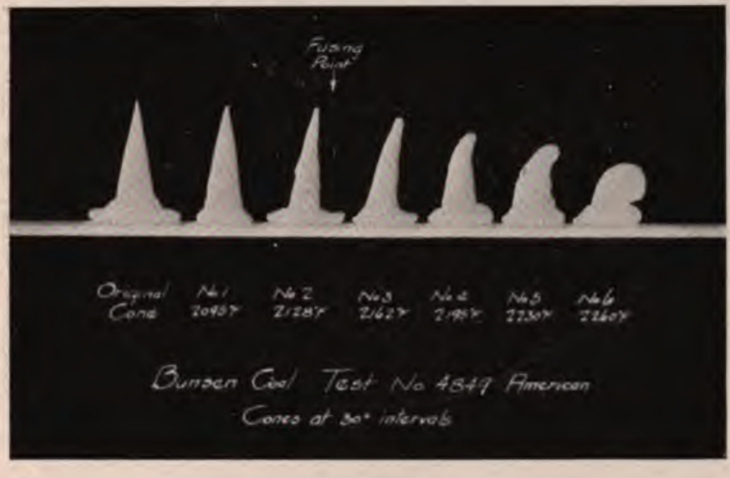

Fig. 2.

-creasing temperature. Excessive troublesome clinkering was experienced in the boiler room when burning this coal. During the fusion test cones No. 3 to No. 6 inclusive, adhered to the brick support in the furnace and were removed with difficulty.

Fig. 3.

Test No. 4516-B (Figure 3)

This coal comes from Ohio and although the ash is low for mines in this locality, the nature and extent of the clinker formed at ordinary boiler loads make it a most undesirable fuel. The test was made under Wickes boilers with Detroit stokers at moderate boiler loads, the report from the boiler room stating "that the coal forms a pasty clinker, sticking to the grates and putting out the fire." The following results were obtained in the laboratory:

Analysis of Coal

Volatile matter %	41.69
Fixed carbon %	47.41
Ash %	10.90
Sulphur %	2.278
B. T. U. per lb. of dry coal	12687

Analysis of Ash

Silica SiO_2 %	36.72
Alumina Al_2O_3 %	25.63
Iron oxide Fe_2O_3 %	30.81
Lime CaO %	1.61
Sulphuric Acid SO_3 %	1.41
Fusing point (cone method) F	1950°
Color of ash	Red-brown
Color and nature of clinker	Blue-black. Very porous

It will be observed that the clinker formation is very voluminous and that softening starts at such a low temperature that at ordinary boiler fire-box temperature this ash would probably quickly melt to a semi-liquid state.

It is interesting to note in the foregoing analysis that high iron content alone appears to be responsible for its extreme fusibility.

Fusing Point of Ash by Pressure Test Using the Fusiometer

While the Cone Method appears quite feasible, and in two years actual use in a commercial laboratory was productive of definite results, the length of time required to properly perform this experiment as well as the personal equation of the operator entering into the judgment of results obtained prevented this test from becoming the definite determination that now characterizes the methods of investigating the volatile ash and sulphur contents or the calorific value of a fuel.

In attempting to devise a more rapid and accurate method of determining the fusing range of a coal ash, it has occurred to the writer that if a sample of ash be formed into a hard pellet under considerable pressure, and this pellet placed in a furnace under a very slight compression, the variation in thickness of the pellet under a steadily increasing temperature will be a measure of the rate of softening at any temperature, the first movement indicating the beginning of the fusing range and the final stage being complete fluidity of the sample. In order to perform such a test, an instrument called the Fusiometer has been devised, which, in indicating, under an increasing temperature, the start and progress of the softening of the test pellet, enables the investigator to make a thorough exploration of the fusing range of the substance under investigation. A test of coal ash under these conditions may be described as follows:

(a) *Preparation of Sample*

As in the Cone Method, a representative sample of the coal is crushed to pass a 60-mesh screen and burned down at a dull red heat to fine ash. The mixing of the resultant ash should be thorough, if concordant results are to be obtained in subsequent fusion tests, since the slightest segregation of the more potent fluxes, which exist in comparatively small percentages in the general sample, will largely influence the position and extent of the fusing range of the ash on the temperature scale. If exact results are required it would probably be advisable to further crush the general ash sample to pass 100-mesh screen before mixing and selecting samples for fusion.

(b) *Formation of Test Pellet*

The test pellet, which is cylindrical in form, $\frac{5}{8}''$ in diameter and from $\frac{7}{16}''$ to $\frac{11}{16}''$ in height, is formed in a hand press similar in construction to the one shown in Figure 4. This press is designed to exert a unit pressure of approximately 25,000 pounds per square inch on the pellet, under which conditions the dry pulverized ash may be compressed into a hard cylinder without the use of a binder. Referring to the sketch, the housing "A" is made of cast steel, the mould "E," plunger "D," and plug "F" of tool steel, hardened and ground to a sliding fit with one another. With the plug "F" held in position as shown, the mould is filled with a representative

ash sample, the plunger inserted and forced downward until maximum compression is obtained. The screw is then backed off and the mould lifted from the groove in the housing and turned through

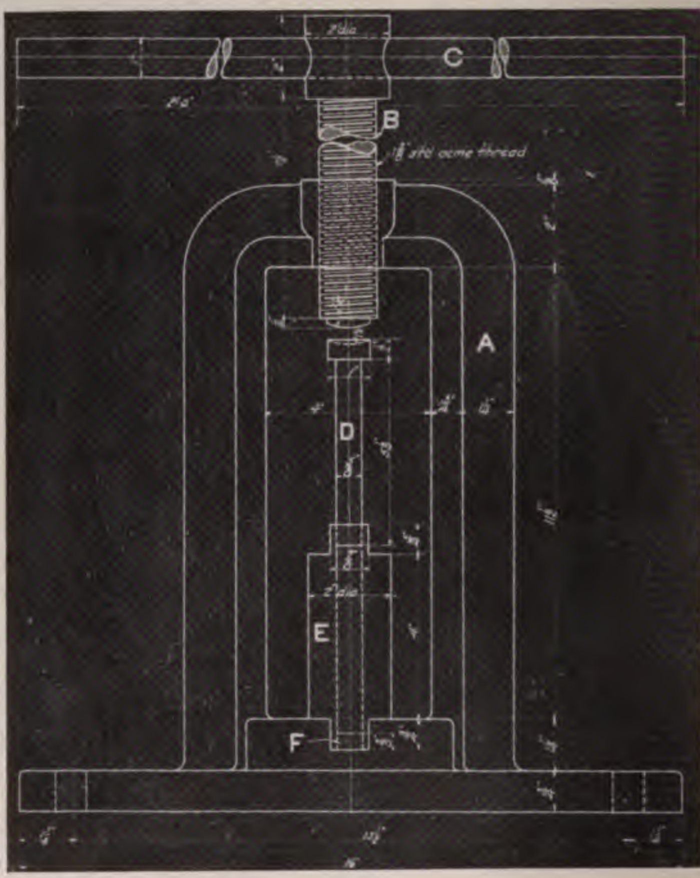

FIG. 4.

a 90° angle. Pressure is again exerted and the plug "F" and ash cylinder forced out in turn.

(c) *Description of Fusiometer*

After experimenting in the construction of various designs of this instrument, the form shown in Figure 5 was adopted as being

best suited, mechanically speaking, to carry out the proposed fusion tests. The test pellet "W" is held centrally in the furnace "A" by the carbon rods "C" and "D." These rods are ordinary arc lamp carbons ½″ in diameter. Rod "D," which supports the test pellet, is immovable in the position shown, being held by the clamp "E" to the bottom of the furnace body. Rod "C" and weights "L" and "N" are free to move in a vertical direction, and in this particular instrument are designed to exert a unit pressure of 1.5 pounds per square inch on the pellet. Rod "C" is held on the center line of the instrument by four guide wheels as shown. A silk cord connects the rod "C" and weights "N" with the pivoted pulley "S" and counterweight "P." The pointer "V" is fixed to the pulley "S" and indicates on the scale on plate "U." The pulley "S" is one inch in diameter and the pointer six inches long so that any vertical movement of the carbon "C" due to softening of the test pellet "W" is magnified twelve times on the scale, the total collapse of a pellet ⅝″ in height being indicated by a movement of the pointer over 7½ units on the scale. The several parts of the instrument are supported on two 1½″ diameter rods, fixed in a heavy cast iron base, this construction being considered necessary to obtain proper rigidity of the fixed points.

In experiments carried out by the writer, a gas heated furnace was used, the position of the burner being at "B." The carbon "D" is protected for a part of its length from the direct action of the flame by a porcelain tube as shown. When this method of heating is used, the carbons slowly reduce in diameter and, from time to time, must be replaced by fresh rods. From six to eight tests may be completed with one pair of rods, without excessive reduction of the rod diameter. Temperature measurements are made with a platinum rhodium thermo couple. The porcelain protecting tube for this couple is shown in position in the sketch, so that the couple bead is in close proximity to the ash pellet.

(d) *Method of Making Test*

With the ash pellet and carbons in the position shown, and the pointer "V" adjusted midway between zero and 1.00 on the scale, the furnace is gradually heated up at the rate of from 50° F. to 100° F. per minute, simultaneous temperature and scale readings being made at one-half minute intervals. As the heat is increased, negative movement of the pointer will indicate carbon expansion

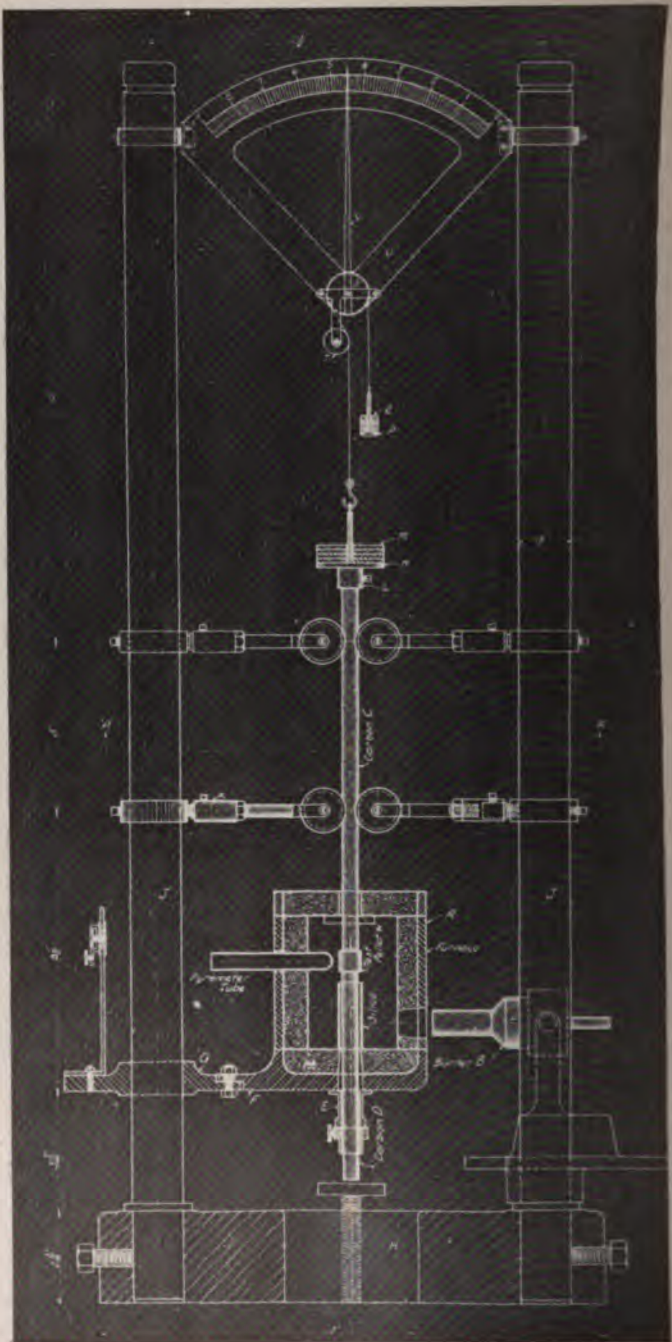

FIG. 5.

up to a temperature where the first softening of the ash pellet is indicated by a positive movement of the pointer. The experiment is continued till the final collapse of the pellet is indicated on the scale.

These results if plotted, the temperatures as abscissa and the scale movement as ordinates, produce a curve, an ordinate of which at any point is a measure of the relative rate of softening of the ash pellet at that temperature. This curve is parallel to the temperature axis at the first softening of the ash, becoming parallel to the scale axis at or near the melting point, thus giving a diagram of the complete fusing range of the ash under test.

(e) *Interpretation of Results*

Length of the softening range and its position on the temperature scale in relation to the working temperature range of a boiler fire, as well as the increasing rate of softening with increasing temperature, whether gradual throughout the range, indicating high viscosity, or very slight for most of the range followed by a sudden collapse, are the factors in the Fusiometer results which must be considered in predicting the probable clinkering action of a coal in a boiler fire.

A long range ash with a slow but steady increase in softness, apparently indicated by the gently sloping curve, is productive of the close gummy clinker of high viscosity. This type, provided the softening range coincides approximately with the working temperature range of the boiler, produces the greatest losses from clinker formation in a boiler fire.

The other type of ash fusion is a short range spongious, porous formation of low viscosity, which, if it does not occur too low on the temperature scale, can be handled with ease in the boiler fires, the only loss occurring as increased coke in the ash pit and carbon monoxide in the flue gases. The Fusiometer curve for this type of fusion is distinguished by a most decided downward dip in the curve just prior to final softening.

As previously stated in this discussion, the term "fusing point" is misleading and indeterminate, while "fusing range" of a substance can be determined with exactitude. However, for purposes of relative comparison, an arbitrary point in the fusing range may be selected and called the "fusing point" of the ash. For this point, in the case of the Fusiometer results, the writer suggests the

calibration presents itself. Test cylinders of pure metals or standard substances having sharply defined melting points are placed in the furnace "A" in the usual position for an ash cylinder, and the fusing curve developed as described in the previous paragraphs. Since the Fusiometer was designed primarily for the investigation of coal ash fusion, its working temperature range will be between 1900° F. and 3000° F. It has, therefore, been considered sufficient, in calibrating this particular instrument, to develop two points only, and for this purpose nickel and copper were selected.

It will be noted in Figure 6 that the copper point is sharply defined, the two curves substantially checking and showing a very short softening range. The nickel point is also sharply defined, but this metal appears to have a longer softening range in comparison to copper.

The following illustrations show curves developed from a number of ash tests, using this instrument, together with Boiler House reports in regard to the nature and extent of clinker formed under actual operating conditions.

Tests Nos. 6983 and 7101—(Figure 7)

Both of these coals, which were mined in Middle Pennsylvania, were tested under Rust Boilers with Taylor Stokers, using a forced draft equivalent to two inches of water in the ash pits. The laboratory results were as follows:

Test No.	6983	7101
Volatile Matter %	27.32	22.00
Fixed carbon %	63.61	71.70
Ash %	9.07	6.30
Sulphur %	1.705	1.172
B. T. U. per lb. of Coal	14079	14622
Fusing point of Ash F.	2233°	2311°
Nature of clinker	Porous	Close—hard

Boiler House Report.

No. 6983.—This coal burned freely, with a long flame, the only undesirable point being the formation of large clinkers, which did not, however, cause a serious amount of trouble.

No. 7101.—Proved so troublesome on account of clinker formation, that the remaining cars of this shipment were rejected. Required 45 minutes to clean fires after six hours running.

It is rather interesting to note that although there is less than

100° F. between the final softening temperatures of these two ashes, the one having the higher melting point (Test No. 7101, Figure 7, Curves No. 3 and No. 4), gave the most trouble in the boiler room. From the shape of the curves and the nature of the final pellet fusion, the latter ash has a long fusing range, a high viscosity throughout the range, and finally forms a close gummy clinker,

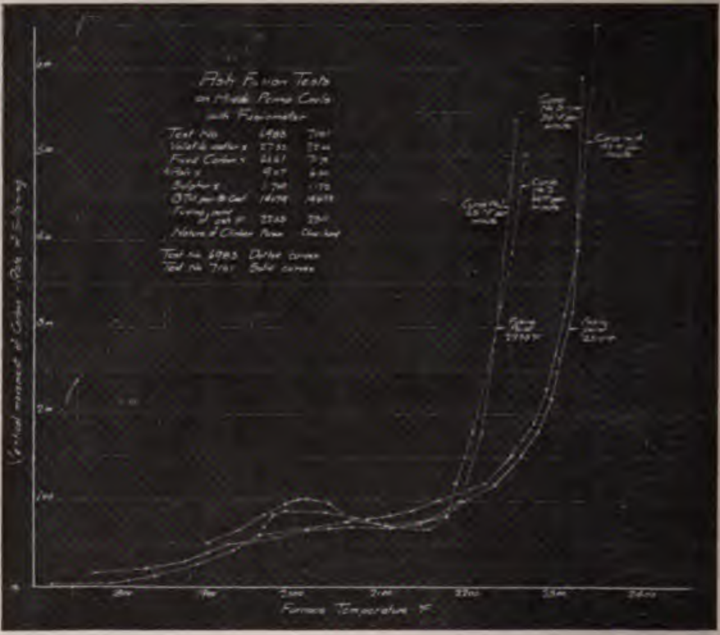

Fig. 7.

difficult to remove from the dead grates of a boiler fire box at cleaning periods.

In like manner, for Test No. 6983, Figure 7, the dip in curves No. 1 and No. 2 indicates low viscosity of the meld and the formation of a porous clinker, easily broken up and removed from the fire box.

These two samples illustrate the wide variation in viscosity of meld, between ashes fusing at approximately the same temperature, and the futility of using only the relative ash fusing temperatures to grade coals as to their probable freedom from clinkering trouble, without considering also viscosity and length of softening range.

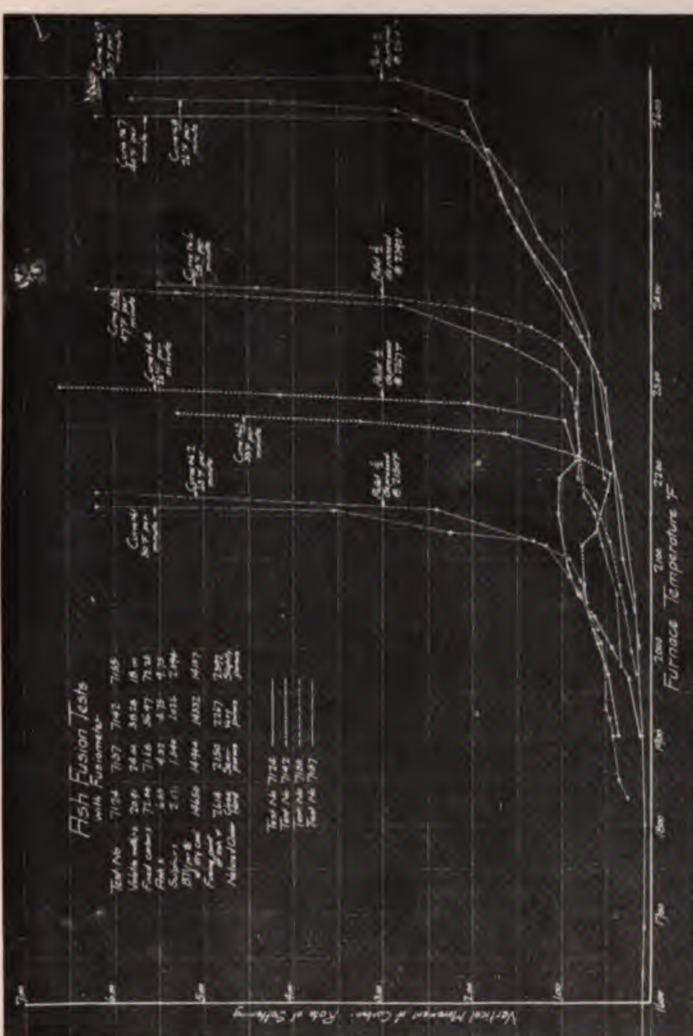

Fig. 8.

Tests Nos. 7124, 7137, 7142, and 7155—(Figure 8)

These coals were mined in Middle Pennsylvania, except No. 7142, which was a slack gas coal from West Virginia.

Test No.	7124	7137	7142	7155
Volatile Matter %	20.91	24.00	38.28	18.00
Fixed Carbon %	72.54	71.68	56.97	72.25
Ash %	6.55	4.32	4.75	9.75
Sulphur %	2.171	1.540	1.026	2.594
B. T. U. per lb. of Coal	14650	14944	14332	14137
Fusing point of Ash F	2614°	2150°	2267°	2392°
Nature of clinker	Close-hard	Semi-porous	Very porous	Slightly porous

Boiler House Report.

No. 7124.—Free burning long flame coal—burning at a high temperature. The writer witnessed one cleaning of the fire after six hours' operation, at which time it required only the dumping of the back grates to completely clean the fires, this operation consuming two minutes. At other periods it was claimed that this coal gave considerable trouble. This could readily occur at 2500° F. due to the high viscosity at this point, as shown by curves 7, 8, and 9, Figure 8.

No. 7137.—A very undesirable fuel on account of the radical clinkering quality of the ash. A tough, gummy clinker formed requiring from twenty to forty-five minutes to remove at fire cleaning periods.

No. 7142.—Free burning long flame coal which burns at a very high temperature. Not entirely satisfactory on account of clinker formed, which, however, can be handled. The combustible loss in the ashes from this coal was high.

No. 7155.—Free burning coal, forming a soft not very troublesome clinker.

High Fusing Ash from Middle Pennsylvania Districts (Figure 9)

These coals were all given a trial under Rust Boilers with Taylor Stokers, under forced draft, using a pressure in the ash pit equivalent to two inches of water. The following analyses were made on the several samples, while curves obtained from fusion tests are shown in the illustration.

Test No.	*6934*	*6921*	*6976*	*7113*
Curve No.	1 & 2	3 & 4	5	6
Volatile Matter %	18.55	17.32	16.86	17.30
Fixed Carbon %	73.84	73.98	74.96	73.55
Ash %	7.61	8.70	8.18	9.15
Sulphur %	0.900	1.042	0.834	0.428
B. T. U. per lb. of Coal	14508	14263	14328	14193
Fusing point of Ash F.	2757°	2923°	over 3000°	2840°
Nature of clinker	All close hard clinker formation.			

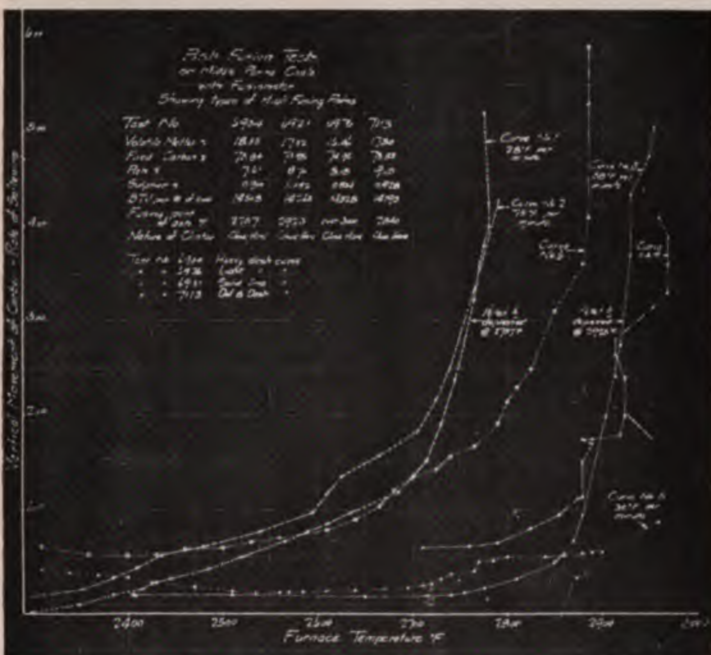

Fig. 9.

Curve No. 3 (Test No. 6921, Figure 9) represents a coal which gave absolutely no indication of clinker in the ash, the dumping of the back grates only being necessary to clean fires. Note the rather short softening range on this ash (Curve No. 3) and its consequent extreme infusibility under 2760° F. Curve No. 4, although an approximate check on the first determination, illustrates the effect of irregular heating on the Fusiometer results. In the Boiler House report, other coals in this group were rated slightly under No. 6921 in quality, but since they all have ashes fusing above

2700° F. and no clinkering of any importance can occur in the boiler fire, a choice of any one coal here represented must be made on the basis of some quality other than that of clinkering tendency.

Middle Pennsylvania Coals (Figure 10)

The following results were obtained from samples representing four test shipments of low volatile coal, burned under forced

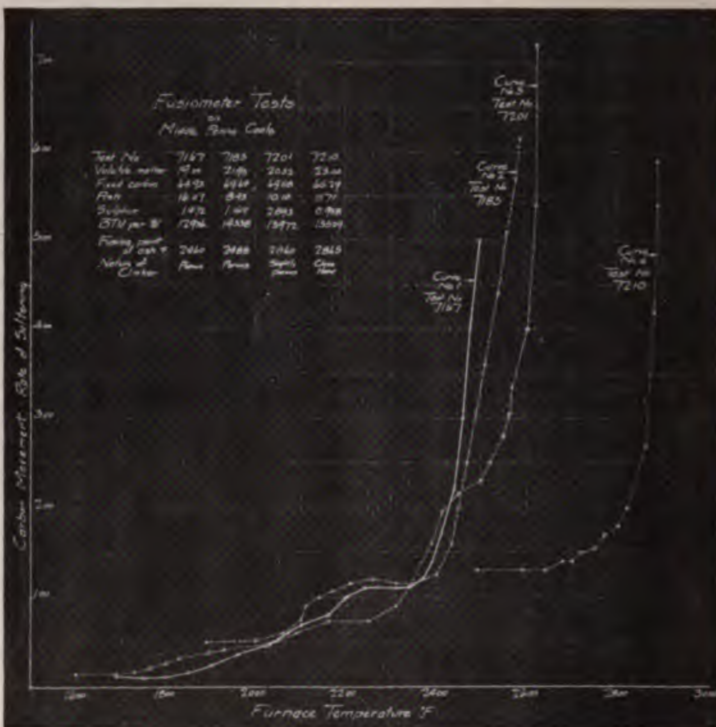

Fig. 10.

draft, with Rust Boilers and Taylor Stokers, at a fire box temperature of from 2400° F. to 2700° F. by Fery pyrometer:

Test No.	*7167*	*7183*	*7201*	*7210*
Volatile Matter %	19.00	21.93	20.32	23.00
Fixed Carbon %	64.93	69.64	69.58	65.29
Ash %	16.07	8.43	10.10	11.71
Sulphur %	1.472	1.169	2.893	0.938

B. T. U. per lb. of Coal	12936	14338	13972	13529
Fusing point of Ash F.	2460°	2488°	2560°	2865°
Nature of clinker	Porous	Porous	Slightly Porous	Close-Hard

In the fusion curves, Figure 10, note the dip in Curves No. 1 and No. 2 indicating low viscosity of the meld.

Boiler House Report.

Test No. 7167.—Made a soft and not very troublesome clinker. Only undesirable quality was high ash content.

Test No. 7183.—Clinker formation easily broken up and removed from fire box at cleaning periods. A satisfactory coal in every respect.

Test No. 7201.—"A very troublesome and undesirable coal on account of its radically clinkering nature." Note the long fusing range of this ash in Curve No. 3, the shape of the curve indicating high viscosity. The writer witnessed three successive cleanings of these fires which required fifty-five minutes, twenty-five minutes, and thirty-seven minutes respectively to perform. The clinker formed was tough and gummy at a red heat, and having arched completely over the dead grates to a depth of six inches, was broken and removed only with the greatest effort.

Test No. 7210.—A free burning coal, satisfactory in every respect with the exception of the ash content.

Duplication of Results on the Fusiometer

Regarding the ability of the Fusiometer to duplicate curves on the same ash sample, an inspection of a number of the curves give the following figures; fusing point taken as the temperature when pellet is collapsed to approximately one-half its original height:

Test No.	*Greatest Variation between Curves in Temp. at 3.00 on Scale*
7122	53° F.—Maximum
7054	9° F.
6934	5° F.
6921	14° F.
6983	0° —Minimum
7101	8° F.
7137	13° F.
7142	26° F.
7155	8° F.
7124	44° F.
Average	18° F.

Variation in the Unit Pressure Acting on the Pellet During Fusion (Figure 11)

For the purpose of experiment, the Fusiometer was reconstructed so that the unit pressure on the pellet was 32 pounds per square inch. An Ohio coal, the ash of which had a long softening range, was selected for the test. Curve No. 1, Figure 11, shows the effect of this pressure, while Curves No. 2 and No. 3 show the effect of 0.6 pounds and 1.5 pounds per square inch on the pellet, using the first form of the instrument. A variation of 100% in unit pressure on either side of 1.5 pounds per square inch apparently has no effect in shifting the curve on the temperature scale. The increase in unit pressure to 32 pounds per square inch had the effect of lowering the apparent melting point of the sample 200° F.

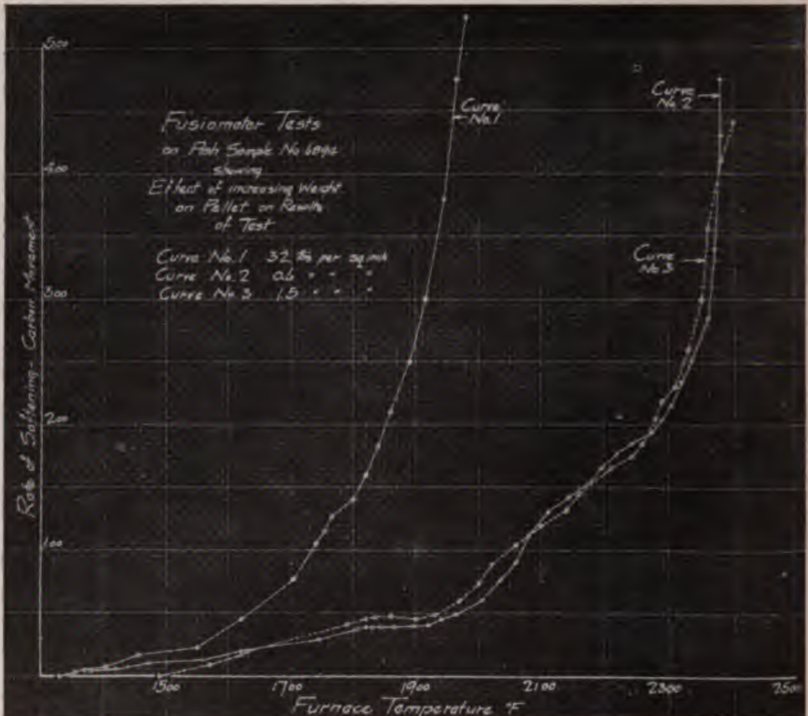

Fig. 11.

Comparison of Fusiometer Results with Those Obtained by Cone Method (Figure 12)

Parts of samples No. 4321, 4330, and 4285 (Illinois coal) were selected for comparison of these two methods, a period of three years time intervening between the date of making the cone tests and the time when Fusiometer results were obtained. Note the low viscosity indicated by the dip in Curve No. 3 and the higher viscosity indicated by Curves No. 1 and No. 2, Figure 12.

Test No.	4321	4330	4285
Curve No.	2	1	3
Volatile Matter %	33.45	36.18	33.09
Fixed Carbon %	45.15	48.38	55.39
Ash %	21.40	15.44	11.52
Sulphur	4.118	1.459	1.308
B. T. U. per lb. of Coal	11040	11510	12562
Fusing point of Ash F. (a) Cone Method	2280°	2370°	2395°
Fusing point of Ash F. (b) Fusiometer	2215°	2270°	2365°
Nature of clinker	Close-fairly hard	Close-fairly hard	Porous brittle

Considering that the above temperatures are more or less arbitrary points selected in the fusing range determined by two methods, the agreement between the results is fairly close. The cone method has the advantage of requiring a somewhat simpler form of apparatus and also enables the operator to have the sample under observation in all stages of the softening. The proper performance of this experiment, however, requires from six to eight hours, exclusive of the time required to burn down the coal. The personal equation of the investigator also enters to a greater extent into the judgment of results by this method than with the Fusiometer. The Fusiometer method is quick, requires no binder in the formation of the test pellet, and successive tests on the sample check closely. The curve developed from results gives a fair picture of the softening of the sample throughout its fusing range. Regarding the time required to make tests on this instrument, eight tests, including making of pellets, were performed in three and one-half hours, averaging twenty-six minutes per test. This time compares favorably with the time required to make a proximate analysis or a B. T. U. determination. During this per-

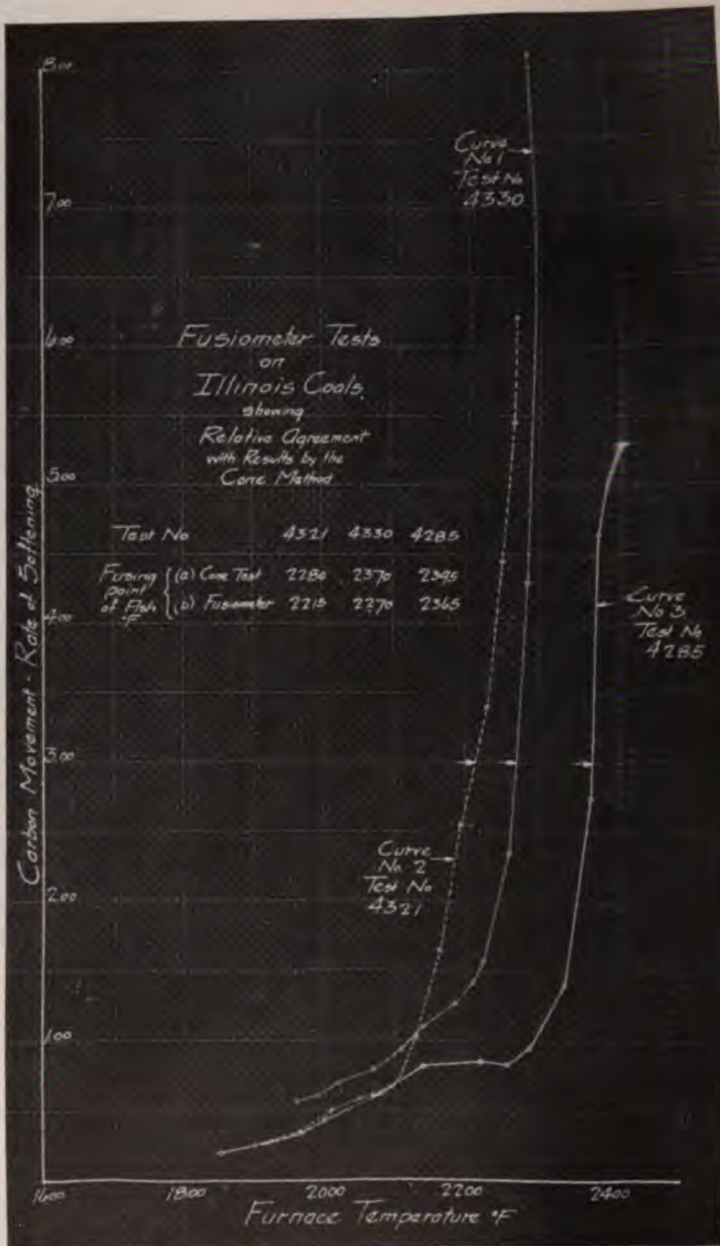
Fusiometer Tests
on
Illinois Coals
showing
Relative Agreement
with Results by the
Cone Method
Test No 4321 4330 4285
Fusing point of Ash °F (a) Cone Test 2280 2370 2395
(b) Fusiometer 2215 2270 2365
Curve No 1 Test No 4330
Curve No 2 Test No 4321
Curve No 3 Test No 4285
Carbon Movement · Rate of Softening
1600
1800
2000
2200
2400
Furnace Temperature °F

Fig. 12.

formance the carbon rods were reduced from ½ inch in diameter to ⅜ inch diameter at the pellet. Frequent replacement of the carbons may be made since their cost is negligible (1¾ cents per carbon 12″ long).

Results by the Fusiometer in Comparison with Results Obtained in the Boiler Room

In regard to a comparison between laboratory results and those obtained in the boiler room, Somermeier notes "that fusibility of well mixed ignited ash, and fusibility of the ash in the coal during combustion in a furnace, are two entirely different things. The first is dependent upon the constituents of the ash as a whole; the second is dependent on the nature and distribution of the different minerals in the coal acting separately or only partially mixed."

These are undoubtedly the existing conditions in laboratory test and boiler fire box. Segregation of the impurities is prevalent in soft coal; in fact, this is the feature which makes representative sampling of steam coal so difficult a matter and a subject of continual dispute between Buyer and Seller when price is based on analysis. It is also true that in the laboratory sample and test for fusion this segregation is carefully eliminated in order to obtain a mean result. However, considering the curves and criticisms on the foregoing pages, it would appear that this form of test, if properly interpreted, should be of value in grading coals as to their clinkering tendency, and, in connection with the present standard methods of proximate analysis, be used in the prediction of the probable value of a fuel to a steam boiler plant.

Fusing Point of Ash from Ultimate Analysis

Although it appears impracticable to approach this problem from the analytic side—both from the length of time required to perform an ash analysis and the impossibility of determining from this analysis even the probable form or combination of the ash constituents in the original coal as mined—the attempt to relate the fusing point of the ash with its chemical composition will at least give an insight into the cause of the wide variation in fusing point of bituminous coal ashes.

For the purpose of this investigation, twelve samples of bituminous and semi bituminous steam coal were selected as nearly as possible to represent the fields and districts of Middle Pennsyl-

	Curve No.	1	3	4	2	5	6	7	8	10	9	11	12
	Test No.	4516	6395	4376	6454	6394	4353	4330	4285	4337	4227	4013	4152
	Name of Coal	Saltillo	Black Oak	Springfield	Moshannon	Black Oak	Vein #6 Nan Boden Mine	Bungen Kelley Mine #4	Cambridge Black Top Mine	South Fork	Pardee	Somerset Jenner	Irvona
	Location of Mine	Ohio	Clearfield Penna	Ebensburg Penna	Clearfield Penna	Clearfield Penna	Illinois	Grape Creek Illinois	Ohio	Portage Penna	Cambria Penna	Somerset Penna	Middle Penna
Analysis of Coal	Moisture %	5.00	3.59	5.16	4.22	3.28				3.75	3.38	2.83	3.84
	Volatile Matter %	41.69	23.34	20.75	22.37	24.30	38.03	36.18	33.09	18.42	23.16	22.92	23.47
	Fixed Carbon %	47.41	67.49	74.60	71.13	64.40	43.88	48.38	55.39	73.55	69.99	68.63	67.03
	Ash %	10.90	9.17	4.65	6.50	11.30	18.09	15.44	11.52	8.03	6.85	8.45	9.50
	Sulphur %	2.278	2.013	0.918	1.162	0.868	4.178	1.459	1.308	1.16	0.640	1.018	0.420
	BTU per lb dry coal	12687	14097	14847	14499	13771	11541	11510	12562	14320	14519	14237	14056
Analysis of Ash	Silica SiO_2	36.72	36.72	39.26	46.04	53.50	43.74	40.88	47.36	46.22	51.20	52.62	45.36
	Alumina Al_2O_3	25.63	27.66	24.94	24.07	26.10	18.06	19.27	29.43	37.95	33.44	31.70	37.90
	Iron Oxide Fe_2O_3	30.81	28.50	26.60	23.63	10.37	21.18	14.85	12.23	10.61	8.16	7.04	7.23
	Lime CaO	1.61	1.80	2.78	1.86	1.30	7.24	10.94	3.88	1.00	1.64	1.06	2.28
	Magnesia MgO		0.59		Trace	Trace	0.48	0.47	0.54	-	Trace	Nil	-
	Sulphuric Acid SO_3	1.41	2.27	2.35	1.79	1.33	3.74	6.40	2.69	1.15	1.39	0.98	1.45
	Ratio Acids to Bases	.458	.467	.507	.661	.890	.738	.718	.690	.588	.732	.810	.602
	Prost's Modulus	1.54	1.89	1.505	1.385	3.19	.75	.98	3.06	7.28	6.04	6.62	9.34
	Fusing point of Ash °F	1950	2160	2175	2100	2230	2255	2370	2395	2935	2930	3030	3140

Fig. 13.

vania, Ohio, and Illinois. From these samples, portions were selected for the regulation proximate analysis and B. T. U. determination, the remainder being burnt down slowly at a dull red heat to finely divided ash. Portions of these ash samples were then analyzed for constituents while the remaining sample was used to determine the fusing point. On the table, Figure 13, is shown the

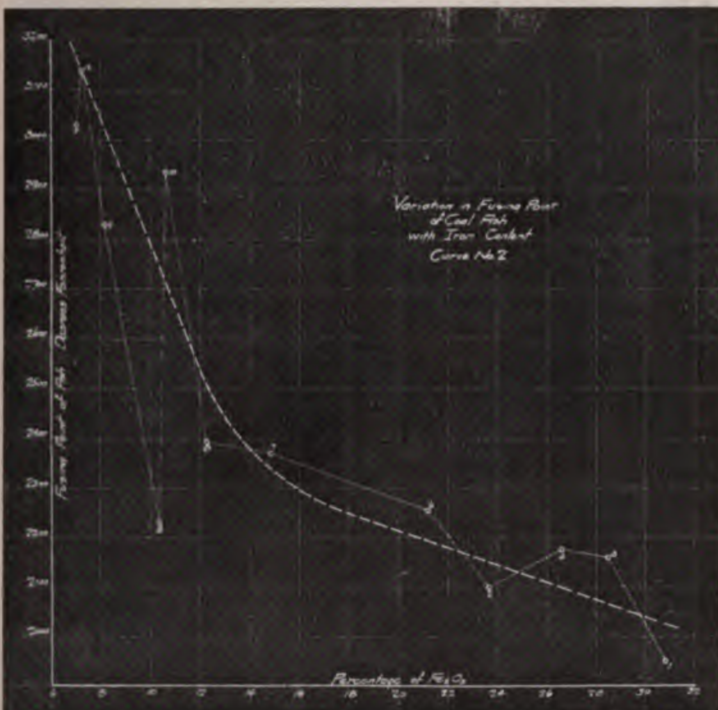

FIG. 14.

result of this work, together with the approximate location of mine which each sample supposedly represents. The samples have been numbered 1 to 12, in the order of increasing melting points.

Coal ash in general may be regarded as a mixture of Alumina, Al_2O_3 and Silica, SiO_2 in major proportion with smaller percentage of iron oxides FeO and Fe_2O_3, Lime CaO, Magnesia MgO, Potash K_2O, Sodium as Na_2O, and Sulphur as SO_3.

Of these compounds, Alumina is the most infusible, melting in the neighborhood of 3300° F., while Amorphous Silica melts at approximately 2900° F., a mixture of these compounds melting at an intermediate temperature which increases as the percentage of Silica in the mixture increases. The other elements appearing in a coal ash may be regarded as fluxes tending to lower the melting point of the Alumina-Silica compound. Iron appears to be a potent flux and in the twelve samples of ash selected for analysis varies from 30.81 per cent. to 7.04 per cent. Its relation to the melting point follows a fairly definite law as shown by Curve No. 2, Figure 14. Sample No. 5 appears to be the exception, being low in iron content and fusing point. The cause of this variation was not determined by actual analysis, since a further investigation of the sample for sodium and potassium salts gave negative results.

From an inspection of the table of ash analysis, no single relation between the lime content and fusing point is apparent. It is rather interesting to note that in the case of samples No. 6 and 7, high lime content is not accompanied by a particularly low fusing point; also that the more fusible of these two samples has the lower lime and higher iron value. Similarly, the sulphur content does not follow any particular rule, the maximum amount being found in Sample No. 7.

In general it may be stated that the higher fusing ashes show a tendency to high alumina while the silica content, when considered alone, does not show any relation whatever to fusing temperature.

Prost's Formula (Manual of Chemical Analysis) for slags, in which the fusing point is made directly proportional to the square of the alumina content and inversely to the product of the silica with the sum of the iron, lime, and magnesia, has been applied to the twelve ash samples, with the results shown in No. 3 curve, Figure 15. Curve No. 3 also shows the result of another combination of the ash constituents, called the "F" modulus, which, when applied, appears to form a somewhat more regular curve than that produced by the Prost formula. In this modulus the fusing temperature varies directly with the sum of the alumina, iron, lime, and magnesia and inversely as the product of the silica and iron. The value of either of these formula from a commercial standpoint, even though they were found to be accurate and applicable to all cases, is in part vitiated by the difficulty and expense attached to an ultimate chemical analysis of coal ash requiring from 16 to 24 hours to perform.

either by the Prost or "F" modulus, and requires only a knowledge of the silica and iron content. Considering only the twelve ash samples plotted, the maximum temperature error obtained by using this curve would be 160° F., in the case of Ash No. 6.

Four ash analyses selected at random and made at a later date than those used in the foregoing curve are shown in the following table. It is of interest to note that of these four analyses two agree closely with the "H" curve, while the others do not.

Sample No.	*6934*	*6983*	*7137*	*7201*
SiO_2	42.65	41.47	30.98	34.87
Al_2O_3	36.96	29.71	27.01	25.52
Fe_2O_3	12.82	24.22	34.36	34.74
CaO	3.07	1.14	1.27	2.55
MgO	.67	.93	.51	.47
SO_3	1.21	.96	2.64	1.48
P_2O_5	.06	.05	none	trace
CO_2		none		
Alkalies	none	none		
Carbon	2.10	.67	2.86	.5 (est.)
Total	99.54	99.15	99.63	100.13
Modulus "H"	.107	.058	.0648	.537
Fusing point by Fusiometer F.	2757°	2233°	2150°	2560°

Somermeier states "mixtures extremely high in either acid or basic compounds are not readily fusible." With this statement in view, the ratio of acid to basic constituents has been calculated, but the plot of fusing temperature against this ratio did not produce the smooth curve anticipated.

Fusing Range of Ash Constituents by Fusiometer Method

The Fusiometer affords an easy and quick method of investigating softening temperatures of ash constituents as well as possible combinations of these constituents in the coal ash. Aluminium oxide and lime, considered singly, are, of course, highly infusible. The softening range of other constituents, some of which are here shown, Figure 17, cover a wide range on the temperature scale.

Ferrous Sulphide (FeS). A common form of sulphur in coal is pyrite (FeS_2) which at low temperatures gives up half of the sulphur, becoming ferrous sulphide (FeS), a very fusible compound.

Curves Nos. 1 and 2 show this compound melting at 1660° F. with a very short softening range.

Ferric Oxide (Fe_2O_3). Red oxide of iron may exist in the ash originally, or may be produced during combustion on the grates from pyrites. Curves 4 and 5 show that softening starts at 1900°

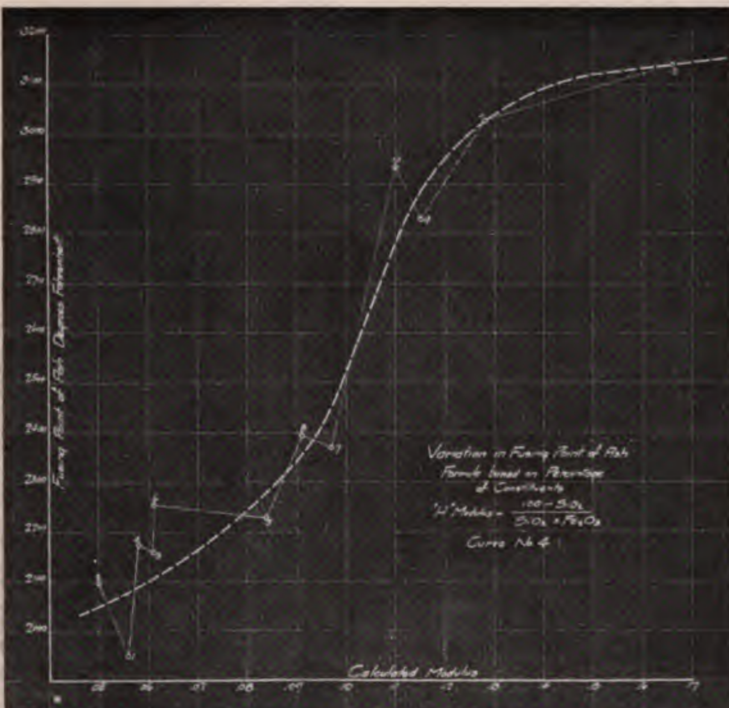

Fig. 16.

F. and continues at a more or less uniform rate up to the melting point at 2600° F.

Calcium Sulphate ($CaSO_4$). Occurs in coal as very thin white partings. When heated, the first softening occurs at 1600° F. and the final melting at 2500° F.

The considerable expansion of a pellet of this substance, between 2100° F. and 2350° F. or prior to the melting point, would indicate the evolution and release of a gas between these temperatures. The writer is still seeking an explanation of this occurrence, since

this curve was reproduced a number of times both in shape and position on the temperature scale, first in the presence of reducing agents and later with the carbon rods covered with platinum ferrules and an excess of air in the furnace gases.

The curves for calcium sulphate and the red oxide of iron are interesting, since they represent, in shape, the two extremes of coal ash fusion. Of the total number of ash samples tested by this

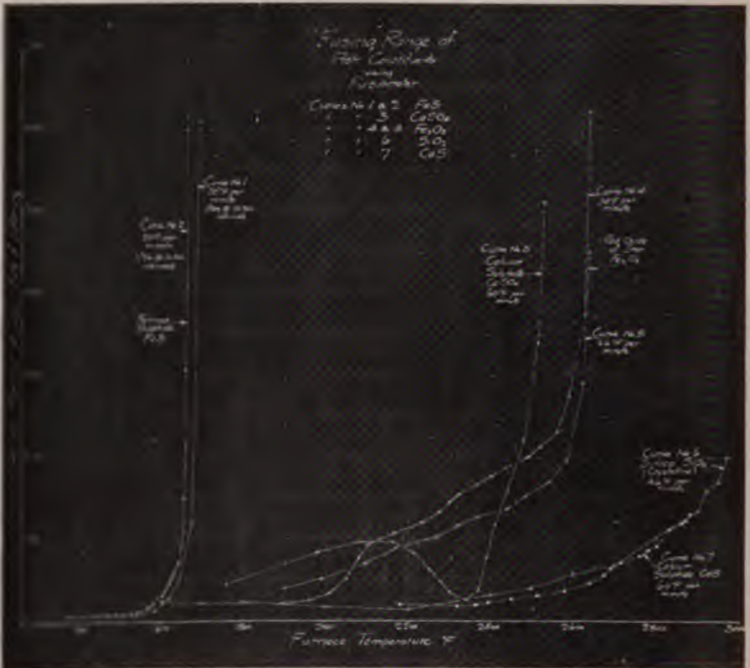

Fig. 17.

method, a large percentage of those melting between 2100° and 2500° F. show indications in varying degree of the dip in the calcium sulphate curve. Also—and this fact has been confirmed by Boiler Room results in approximately fifty test shipments of coal from a number of districts—a coal ash producing a fusion curve similar to that of the sulphate, shows a low viscosity of meld and will produce a porous brittle clinker easily broken up and removed from the fire box, while an ash producing a curve similar to the ferric

oxide fusion indicates high viscosity and the production of a tough, gummy clinker difficult to break up and remove from the fire box.

The first type of fusion, while causing no excessive delay at cleaning periods, is productive of dirty fire and a high percentage loss of carbon in the ash pits.

The second type not only causes delay at cleaning periods, but increases the wear on the grate bars and brick work, in addition to cutting down the capacity and efficiency of the boiler as a whole. One of the effects of this type of fusion is to arch over the back grates on a stoker, preventing the admission of air necessary to economically burn down a fire preparatory to cleaning.

Silica (SiO_2). Silica in the amorphous form melts at 2900° F. while in the crystalline form it fuses at 3170° F. Curve No. 6 shows the beginning of the fusion of a pellet of crystalline silica, only slight vitrification occurring at 2970° F.

Calcium Sulphide (CaS). This compound is very similar to SiO_2 in infusibility. Curve No. 7 shows the similarity of these two compounds in this respect.

Silicates of calcium and iron may exist to a large extent in coal ash, while the sodium and potassium salts seldom occur to any noteworthy degree. Aluminium silicate is well known for its infusibility, this characteristic for a long time preventing the manufacture of the artificial emerald. In regard to ferrous silicate, Hofman (Trans. A. I. M. E. Vol. 29) gives the melting points of three forms of this substance at 2340° F., 2080° F., and 2030° F. respectively. These figures have been quoted in certain discussions on clinker formation, in which ferrous silicate is considered as an existing constituent in a low fusing coal ash and a factor in the clinker formation. In an endeavor to make a form of ferrous silicate for laboratory experiment (probably $FeSiO_3$) the writer found this substance extremely unstable, reverting slowly to ferric silicate in contact with air at ordinary temperatures, or quickly, upon the slightest application of heat. It would, therefore, appear that any combination of the silica and iron in coal ash is in all probability in the form of ferric silicate in the fuel bed, which compound in the amorphous state by fusiometer test is highly infusible under 2900° F., showing only the slightest vitrification at this temperature. Barium silicate, though quite fusible at 2490° F., does not exist in coal ash. On the Fusiometer it shows a long

softening range starting at 1600° F. and ending at a temperature slightly over 2500° F. in complete fluidity. In like manner Calcium Silicate, a more probable constituent of coal ash, shows an extremely high viscosity throughout its softening range which extends from 2400° F. to 2850° F., without great fluidity at any temperature in

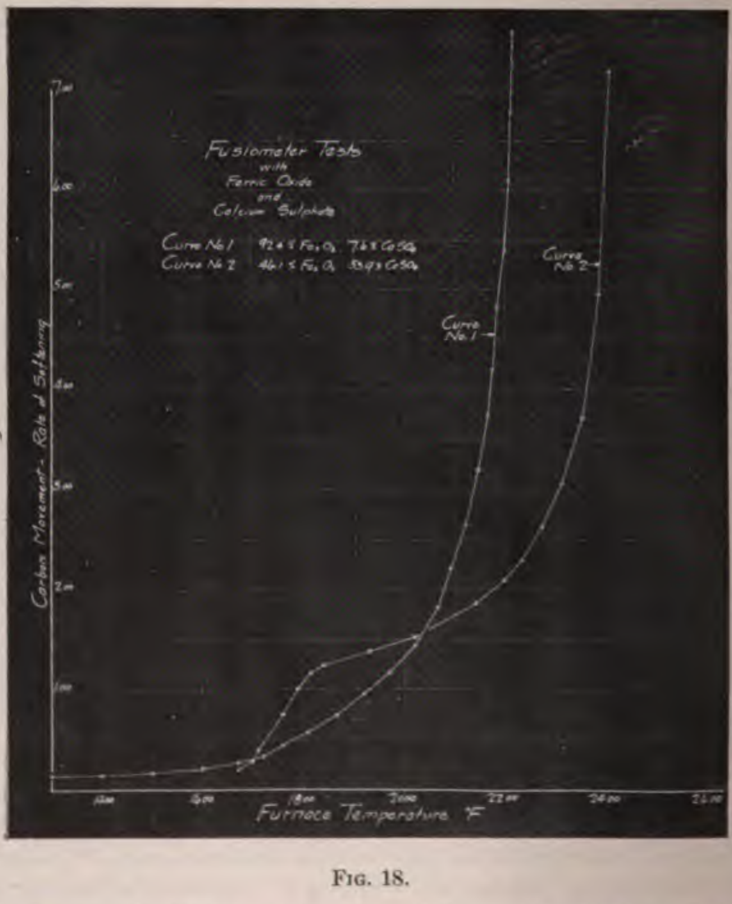

FIG. 18.

this range. Authorities give the melting point of this substance at 2750° F. Calcium Aluminate ($CaAl_2O_4$) starts to soften at 2250° F., reaching great fluidity at 2830° F.

Referring again to the shape of the fusion curves for calcium sulphate and ferric oxide, the following curves, Figure 18, show results from mixtures of these two compounds, No. 1, in which the

iron predominates, and No. 2, in which the calcium sulphate is slightly in excess. No. 2 curve shows an indication of the typical dip of the sulphate curve, while No. 1 curve is similar to the iron curve, but showing a higher viscosity of meld and less definite final softening. Both of these mixtures melt much below the fusing temperature of either constituent, the smaller percentage of $CaSO_4$ apparently having the greater fluxing effect.

Probable Form of Ash Constituents in Coal as Mined

While this question is highly involved, it may be capable of ultimate solution, by trial, with synthetic mixtures based on the ordinary ash analysis obtained by the chemist. However, on account of the multiplicity of possible combinations of constituents, this operation would require considerable time and labor, even though a quick and accurate method of determining the softening range of any one mixture is available.

A number of trials were made, based on Test No. 4516, the analysis of which is given below, in which the relative fluxing value of certain minor constituents is demonstrated—assuming, first, that the silicon, aluminium, and iron exist as oxides in the original ash.

Original Ash Analysis

Silica SiO_2 %	36.72
Alumina $Al_2 O_3$ %	25.63
Ferric Oxide $Fe_2 O_3$ %	30.81
Lime CaO_3 %	1.61
Sulphuric Acid SO_3	1.41

The Fusiometer curves for the following synthetic mixtures are shown in Figure 19.

First Mixture.—The sulphur as FeS, ferrous sulphide, the remaining iron as Fe_2O_3, ferric oxide, and the other constituents in the proportion and form shown in the original analysis. This mixture had the lowest melting point of the series, this temperature agreeing more nearly with the cone test of the original ash which was given as 1950° F. Curve No. 1, Figure 19, was obtained for this mixture, which is somewhat similar in shape and length of softening range, but not in position on the temperature scale, to the FeS curve shown on the previous illustration.

Second Mixture.—Sulphur as calcium sulphide, CaS; the remaining calcium as lime CaO, with the other constituents in the

proportion and form shown in the original analysis. Curve No. 2 shows that this mixture has a somewhat higher melting point and viscosity than No. 1 compound. This melting point, however, is far below the melting point of any one constituent. For example:

Compound	*% by Wt.*	*Approx. Melting Pt.*
SiO_2	38.63%	3170 F.
Al_2O_3	26.96%	3300 F.
Fe_2O_3	32.41%	2600 F.
CaO	0.655	Infusible
CaS	1.34%	3100°–3200° F.
2d Mixture	100.00%	2220° F. (Curve No. 2)

Third Mixture.—Sulphur as calcium sulphate, $CaSO_4$, the remaining calcium as lime, CaO, with the other constituents in the proportion and form shown in the original analysis. Curve No. 3 was obtained from this combination, showing a higher melting point and viscosity in comparison to the other mixtures. In this case, the mixture melts very close to the melting point of $CaSO_4$.

Fourth Mixture.—In this combination, the total calcium is considered as lime, CaO, and the sulphur eliminated entirely, in order to determine the fluxing effect of the lime alone, on the alumina-silica-iron mixture. Curve No. 4 shows that this effect is to give a somewhat longer softening range, but a higher fusing point than the CaS lent to No. 2 combination.

Fifth Mixture.—Demonstrating the fluxing effect of Fe_2O_3 alone on the Al_2O_3-SiO_2 mixture, the calcium and sulphur being eliminated. Curve No. 5 thus shows that red oxide of iron may have sufficient fluxing effect on a mixture of this character, to cause clinkering in a boiler fire box, even in the absence of other more potent fluxes. It also appears to demonstrate that calcium sulphate has a tendency to raise the melting point of mixture No. 3.

Sixth Mixture.—No calcium, sulphur, or alumina present, showing the effect of the Fe_2O_3-SiO_2 mixture alone—in the production of a highly infusible combination as shown in curve No. 6, Figure 19.

In order to carry this experiment to a conclusion, since none of the above mixtures give the exact melting point of the original ash, it would be necessary to further experiment with a number of more or less probable combinations, lack of time and materials, in this instance, preventing the writer from doing so.

While the above work is interesting from a scientific standpoint, it can have no value from a commercial viewpoint, since it demonstrates in itself the futility of endeavoring to link the probable clinkering tendency of a coal ash with the results of an ultimate analysis of this ash in a laboratory.

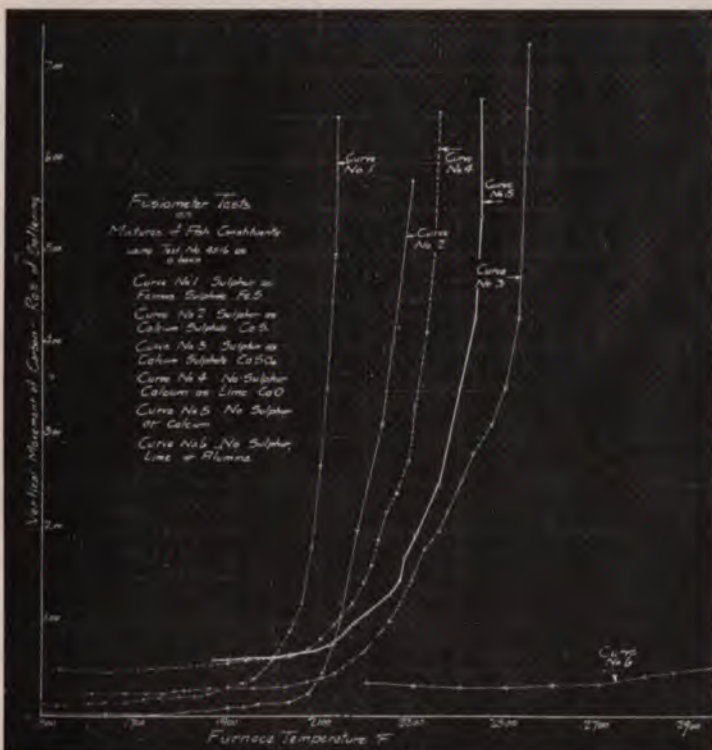

FIG. 19.

VARIATION OF FIRE BOX TEMPERATURE WITH RATE OF COMBUSTION OR BOILER LOAD

The radiation pyrometer, which of late years has been developed into an accurate instrument, has been of great assistance in measuring boiler fire temperatures. In an effort to determine the variation of the fuel bed temperature with rate of combustion, the writer made four boiler tests at widely different loads, during which

the maximum, mean, and minimum fuel bed temperatures were read at frequent intervals throughout each test, using a Fery pyrometer for this purpose. The tests were all made in a Babcock & Wilcox boiler rated at 250 B. H. P., equipped with a Roney Mechanical Stoker using natural draft. The fuel used was a low,

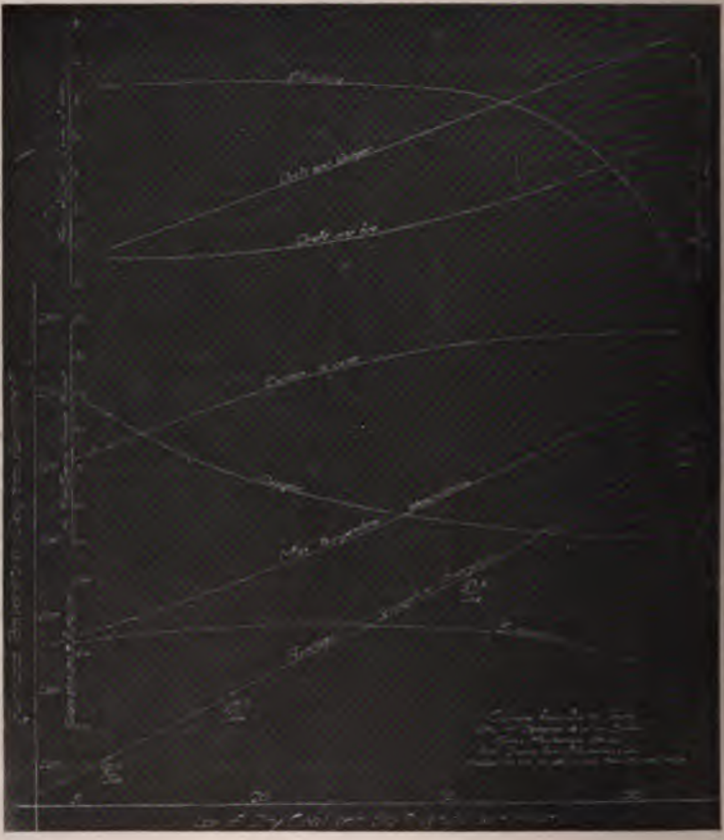

Fig. 20.

volatile steam coal from Clearfield County, Pa., which was low in sulphur, and had a very infusible ash. During the four tests the boiler and stoker were regulated to operate at 95 per cent., 108 per cent., 153 per cent., and 175 per cent. of rating respectively. Curves from these experiments are shown, in Figure 20. Note the smooth curve produced by plotting average fuel bed temperatures

against "dry coal per square foot of grate per hour." It is apparent that when operating at 175 per cent. of rating with this equipment, the average fuel bed temperature is over 2600° F. while a maximum temperature of 2720° F. was reached. The coal ash fused at 3140° F. by the Cone Method, while during the boiler tests, no clinker of any importance was formed, most of the "ash and refuse" being in a finely divided state.

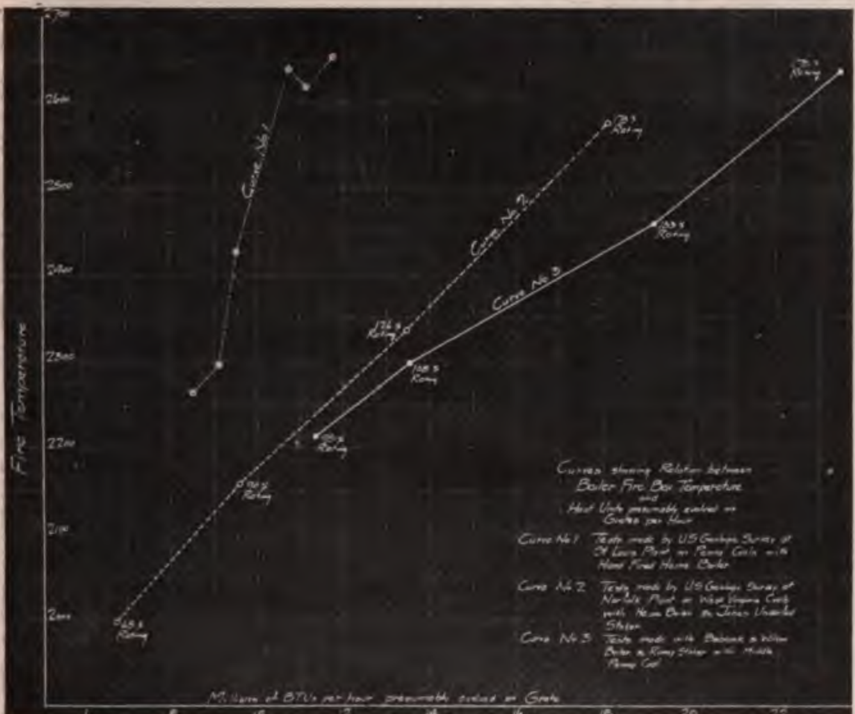

FIG. 21.

Some further information on this subject is given in Figure 21, in which temperature observations taken in the foregoing tests are compared with similar observations made by the U. S. Geological Survey at the Norfolk and St. Louis Testing Stations. Curve No. 1, which represents combustion chamber temperature and not fuel bed temperature, was constructed from observations made with a Wanner pyrometer on Heine hand fired boilers; while curve

No. 2 represents fuel bed temperatures made with the same instrument on Heine boilers with the Jones Underfed Stoker. Curve No. 3 represents results from the tests shown on the previous illustration.

Observations with the Fery pyrometer, covering an extended period, were made by the writer on 588 H. P. Rust boilers with the Taylor Stoker, during which time the average load was 103 per cent. of rating and the average fuel bed temperature 2500° F. The maximum reading was 2840° F. and the minimum temperature 2084° F. This equipment is supposed to be able to care for peak loads of 200% of rating for short periods, at which rate of combustion the fuel bed temperature must necessarily be in the neighborhood of the maximum temperature of 2840° F. given above. On another occasion, during a boiler test, average fuel bed temperatures were around 2750° F., during which time a steady evaporation of 180 per cent. of rating was obtained for approximately one hour from the boiler.

From a consideration of the foregoing fuel bed temperatures, it would appear advisable to purchase coal the ash of which fuses at 2600° F. or over for equipment where high and frequent peak loads must be carried. This temperature specification will not necessarily limit a buyer's choice to fuel from a few districts. In a recent investigation of this nature, 40 per cent. of a large number of test shipments averaged above this figure.

With forced draft equipment, where the rated power is divided into large units and an overload capacity of 200 per cent. of rating must be developed at times, the writer believes that the purchase of a coal with a highly infusible ash should be made without price consideration.

Specifications to Prevent Excessive Clinker Formation in Boiler Fires

In drawing up a specification clause to either eliminate or properly penalize a clinkering coal in proportion to the losses incurred, the variation in boiler load for the plant in question and the relation between boiler load, fire box temperature, and fusing temperature of the ash sample as determined by laboratory experiment must all be accurately known, before such a clause will effectively protect the consumer from loss by clinker formation.

A clinkering clause, based on the Fusiometer determination, is given below in the following form: (This clause has been recently incorporated in certain coal specifications and used in placing new contracts.)

"The entire sample to be reduced by grinding to pass a 60-mesh screen. Portions of thoroughly mixed sample are then to be compressed into cylindrical pellets 5/8" in diameter and approximately 1/2" high, in a steel mould and hand press using about 30,000 pounds per square inch pressure. No binder of any nature to be used. The ash pellet then to be placed in a furnace between the ends of two 1/2" diameter carbon rods, the lower rod fixed and the upper one free to move vertically. A sufficient weight is placed on top of the upper carbon to give a unit pressure of approximately 1.5 pounds per square inch on the pellet. The furnace to be then gradually heated to a temperature where a decided downward vertical movement of the upper carbon indicates that fusion of the ash pellet has occurred. This temperature shall not be under 2700° F., and fusion under this figure shall cause rejection of coal shipment represented by these samples. Temperatures to be determined with a carefully calibrated platinum rhodium thermo couple, with the bead in close proximity to the ash pellet."

This clause, while making no mention of viscosity in connection with temperature, provides in the writer's estimation, a high enough temperature at 2700° F. to ordinarily protect the buyer from clinker formation of the tough gummy variety. Should this temperature be lowered to 2600° F. or 2500° F., in order to broaden the buying field for coal, then some specifications should be made for a low viscosity of meld, as well as temperature of fusion. Certain coal ashes, eventually melting between 2500° and 2600° F., but showing a long softening range and a high viscosity, have given excessive trouble from clinker in the boiler fire box.

Conclusions

(a) To properly grade coals as to their steaming value, it is just as essential to perform a fusion test on the ash as it is to make a calorific determination of the coal.

(b) If 2700 F. or over is specified for the ash fusion and this figure is strictly adhered to in purchasing coal, the buyer will be protected from excessive or troublesome clinker formation in the boiler fires. If a lower temperature is specified, viscosity of meld

as well as temperature of fusion should be considered, keeping the former as low as possible.

(c) The curve developed from the Fusiometer indicates:

1st, Fusing range;
2d, Melting point; and
3d, Relative viscosity of the meld.

(d) That in ash fusion, long softening range is generally accompanied by high viscosity.

(e) The cone method for determining the fusing point of ash, while being fairly accurate, cannot be put into general use on account of the length of time and labor required to properly perform such a test.

(f) On account of the multiplicity of possible combinations of the ash constituents in the original coal, the ultimate analysis of the ash can give only an approximate idea of the possible clinkering qualities of a coal.

DISCUSSION

Mr. A. C. Wood.—The subject discussed by Mr. Hubley is one which I am frank to say I do not know very much about, or at least one I did not know very much about until I had heard Mr. Hubley's very admirable dissertation. I have been making boiler tests for more than twenty years, and have had to do with fuels a good deal in that time. Until very recently, however, I had not given much thought or study to the ash fusion problem.

On account of the high rates of combustion which have become common in the last few years in boiler plant practice, and the resulting high furnace temperatures, we are all beginning to be very much interested in the subject. Some twenty or twenty-five years ago, when rates of combustion of ten to twelve pounds per square foot were the rule, we could burn most any kind of coal without getting into trouble, but now, when we are coming to operate at overloads of 100 to 200 per cent., and to burn from 30 to 45 pounds of our coals per square foot of grate per hour, it is a different proposition. Mr. Hubley brings out the point that iron and silica are the two constituents in ash which cause most of the trouble. We used to think that sulphur was the determining factor, but apparently it is not always so.

Mr. Hubley's paper is a most excellent one, in fact it is to be regarded as a classic. Doubtless there are others here who have worked along the same lines, and can add a good deal more of value to the discussion than I can.

Mr. Hubley.—I would like to correct Mr. Wood's statement, if I may, in regard to sulphur. The two controlling constituents of coal usually seem to be iron in some form and calcium sulphate. The lime and the sulphur in the form of calcium sulphate, and the remaining lime in the form of oxide, seem to be the controlling factor in regard to these curves. A great number of coal companies try to say that sulphur does not cause clinker. The ash will show sul-

phuric acid in a certain percentage; that can exist in coal ash in a good many forms.

PROFESSOR FERNALD.—I think Mr. Hubley should be congratulated upon his presentation of this subject. It is certainly an addition to the literature on combustion of fuel.

This subject is one that has attracted a good deal of attention during the last ten years in connection with boiler tests and investigations of fuel. The Government investigations at St. Louis, Norfolk, and Pittsburgh have accomplished much. There has been a hope that the time would come when we could determine by the analysis of a fuel what evaporation could be secured from that fuel, without going through a long range of expensive boiler tests. The indications are that such a procedure will sometime be possible, but one of the difficulties is the fact that so little is known about furnace design that we have too many unknown quantities in our problem. At the Bureau of Mines station 500 tests were made in one furnace under strict regulation and observation, and yet from these 500 tests it was quite impossible to reach conclusions that would positively fix the question of evaporation from a given fuel analysis without knowing more about the different variables that affected the processes of combustion. The character of the ash seemed to be an important factor.

In the purchase of fuel by specification, this one point fusibility of the ash seems to be lacking. You can determine the quantity of ash and the B. T. U. value, this determining the apparent relative value of the coal, but this does not give any definite information as to how the coal is going to work.

Mr. Hubley's paper would seem to indicate that for power plant purposes, at least when the load is high and the boilers running at one or two hundred per cent. overload, coals with a high ash-fusing point are very desirable. The impression might be gained that low fusing point ash coal would hardly have a market, if we carried this paper to the natural conclusion. I want to point out that there is a distinct use for coals with a low ash fusing point.

In a long series of Government tests it was found that a good many coals could not be used to good advantage in a steam plant owing to the character of the ash and the molasses-like slag that flowed over the grate thus preventing the proper draft through the air passages. These same coals worked splendidly, however, in a gas producer as the temperatures were not so high. Only this summer I saw four commercial producers of about eleven feet diameter, in which the whole process of producer gas manufacture is based on the low fusing point of the ash. These are the blast furnace or slagging type of producers. So far as I know, no plant in the United States is being operated commercially along this line, although, as I say, these four producers were working splendidly in Germany. If the fusing point of the ash is too high, the plant will not operate.

I mention this point simply to bring out the fact that there is a use for fuels with low fusing ash temperature. This subject of ash fusing temperatures is being carefully investigated, and will be further taken up in another paper to be presented at the coming meeting of the American Society of Mechanical Engineers in New York during December.

We find it difficult to draw up satisfactory specifications for the purchase of coal, due to the fact that the types of coal for various classes of work are so dif-

ferent in their character, and the furnaces are also so different, that it is quite impossible to make specifications that will be of real service, as we do not know enough about furnace construction to warrant drawing specifications very closely.

Mr. W. H. Fulweiler.—I have had some little experience in making fusing tests of ash, and one of the disadvantages we have found has been the fact that in most of the methods requiring considerable quantities of air for the ash to be procured, it takes a long time to burn it off in the laboratory and to get good results.

Has Mr. Hubley had any experience with the micro-fusing apparatus that Dr. Burgess, of the Bureau of Standards, has gotten up? It uses only a small quantity of ash. The ash that would result from your usual determination would give you sufficient material to make two or three checks. Having the sample under observation that way, you can see all the phenomena as the temperature rises—how it expands and how it finally runs off into a slag. This would save a great deal of time if it were worked out practically. In my experiments it is impossible with the sample you use as ash to gather up all the constituents each time, and therefore the results have been erratic. I looked over some analyses I had this afternoon, and it would seem that with a temperature of 2700° F. by our method, it would make our source of fuels throughout the Middle West a little bit scarce. I looked over some 72 different brands of coal, and only four of them seemed to give a fusing point above 2700°. Quite a number of them gave up to 2600°, but the majority ran about 2350° and 2400°. I am not so familiar with the bituminous coals of Pennsylvania, but it would seem that 2700° would be a little bit high over the country in general.

In connection with the load factor, where 1½ pounds had been chosen, with no particular object in view, I was wondering whether it would indicate the condition that the ash would find itself under in the fuel bed. We know that the load has to be considered. In working with firebrick we find there are large differences in its resistance to temperature when it is under load and when it is not under load. Some materials are most excellent under low load, but are most worthless under a load that approaches 30 pounds per square foot.

I would like to ask Mr. Hubley whether he has made any careful experiment as to the effect of reducing temperature. We make these little cones and then put them in a place where the atmosphere is probably oxidizing and there is a difference of probably 55° when the furnace becomes reducing in temperature.

Mr. Hubley.—In regard to the oxidizing atmosphere, I followed that out carefully in regard to calcium sulphate fusion, and in that particular case I got a certain shaped curve which was characteristic in shape, of say 50 per cent. of the ash samples tested, and I got this same shaped curve in the same position on the temperature scale, first under highly reducing circumstances, that is, in contact with carbon rods, and running the furnace with a reducing flame, and in the second case by removing these reducing agents. At first I thought the expansion was due to the release of oxygen gas, since the resultant fused mass gave slight indications of the presence of calcium sulphide after the fusion, but later we got the same shaped curve with oxidizing conditions. I put platinum

ferrules under the carbon rods, to remove the reducing influence of the carbon rods in contact with the pellet.

In regard to the pressure on the pellet that was a purely arbitrary weight. My idea was simply to furnish enough weight to overcome the resistance of the moving parts of the instrument in case the resistance of the ash pellet decreased. I had not connected the pressure of the fuel bed in the fire box with this arbitrary weight.

I would like to ask Mr. Fulweiler whether Mr. Burgess has published an account of his fusion apparatus, and whether that was made in connection with firebrick fusion tests.

Mr. Fulweiler.—I do not know. I have seen the apparatus down there. Mostly he uses a little carbon furnace and has a little incandescent lamp in the eye-piece, and he follows the color with a fine rheostat and reads his ammeter, and he uses practically a Morse thermo gauge. He follows the temperature up very nicely and works on very small pieces. I think you will find that if you dry the ash that contains a large amount of iron you will get quite a difference in the fusing point.

Mr. Hubley.—My idea, if such a test was adopted, was to use an electric furnace in which pressure regulates the resistance, and the fusion could take place in an Iridium tube in an atmosphere of nitrogen or hydrogen.

Mr. Fulweiler.—How are you going to do if you have about ten a day to get out? It would probably be an expensive proposition.

Mr. Hubley.—I do not think it would be an expensive proposition. The time required would be comparable with the time required to make a calorific determination of fuel and with the electric furnace you would get more even results, and such an instrument would keep up with the calorimeter, and you cannot turn out results faster than the calorimeter will work. With the instrument shown on the screen I have averaged 26 minutes per test, including the making of the pellets.

Mr. Fulweiler.—How about that 2700° fusing point?

Mr. Hubley.—Very few of the Middle West coals will come up to such a specification. I have seen considerable Pennsylvania coals used in rolling mills in the East. Most of my work has been done in rolling mills here, and we have had to contend with these high fuel bed temperatures. We have plants in the West, but no rolling mills, and our loads are uniform, our boiler capacity is ample, and we manage to get along with certain Illinois fuels.

Mr. Fulweiler.—You would not suggest 2700° for boiler practice?

Mr. Hubley.—I would not suggest any temperature except that which applies to the particular plant. The fixing of this temperature must vary with the nature of the load on the boiler plant, and the location of the particular plant in regard to the surrounding coal fields. Also it must vary with the value that a plant management places on clinker losses, including possible steam failures, against the saving made by purchasing the cheaper and lower fusing fuels. I have not been able to witness any tests in the West—all my information has been hearsay. The Illinois coals are handled in our plants in almost every type

of stoker with natural draught—there is the Murphy, the Detroit, and the Chain Grate, and the Rooney.

A Member.—These results that you have shown, are they all comparable with the original samples of the coal?

Mr. Hubley.—In regard to all the samples that we worked on, these samples were taken according to a standard method which goes with our coal specifications. It starts with 300 pounds on top of the car, taken according to an arbitrary method and reduced by crushing on a canvass to 75 pounds and put through a small crusher and a 10 mesh screen and riffles, and going through smaller riffles and over grinders with a 10 pound sample to a 60 mesh. We have a sampler at our new boiler plant which takes away absolutely the personal equation.

Dr. H. M. Chance.—Was that one great sample?

Mr. Hubley.—Well, we had three cars to each group. This was made of a two pound sample from each car and further reduced by riffles. As a rule the 2700° was specified. I have taken the arbitrary point at which the pellet collapsed to half its original height. In every coal I have tested, I find that at this point the ash is fusing at a very fast rate, and I have taken that arbitrarily and called it the fusing point, and incorporated it in the specification.

Mr. F. C. Freeman.—I would like to ask Mr. Hubley if the ash from coal coming from the same mine but in different shipments would at each time show the same fusibility? Would the variation of fusibility be very great?

Mr. Hubley.—In regard to that question, do you mean taking a sample from a different shipment?

Mr. F. C. Freeman.—Supposedly from the same mine.

Mr. Hubley.—We have found a variation from some mines. For instance, we differentiate between true ash and ash from the partings. Run of mine coal contains a good deal of coal from the partings. Some ash constituents would run high and others low in certain mines, especially in high fusing ashes. In other words, the fusibility of the true ash and "parting" ash will sometimes vary in a mine, therefore, the R. O. M. sample will be affected according to the variable percentage of "parting" ash contained in the R. O. M. sample.

Dr. H. M. Chance.—Mr. Hubley's paper is intensely interesting because it treats the subject in a way that makes it clear to those of us who are not mechanical engineers. It is interesting to learn that even from the standpoint of one who has done a vast amount of experimental work in determining the fusing point of ash that determinations of practical value are difficult to obtain by laboratory experiment. It seems that perhaps the best way to learn the fusing point of the ash of any coal is to burn the coal as in practice under an ordinary boiler. Those who are familiar with the mining of coal know that it is impossible to get a sample that will accurately represent the output from any mine. The taking of a sample from a single car of coal can not be expected to represent the output of the colliery from which it comes for any day, part of a day, or any fixed time. Nearly all bituminous coal is now mined by machines, usually driven electrically, and it is hauled by electric locomotives, in trains con-

sisting of ten, twenty, or more mine cars, from the workings to the mouth of the mine, or to the bottom of the shaft. Each train of mine cars comes from a particular part of the mine and the coal of these cars is representative only of the part of the mine from which they come. When the cars composing this train are dumped, they may perhaps form the principal part or all of the load of a railroad car. As the coal may vary in quality in every room and in different parts of the mine it may have quite different characteristics; there being no uniformity of composition, it is evident that a sample to be representative must contain coal from all parts of the mine.

Not only does the coal-bed in different parts of a property vary in thickness and character and in the percentage of ash, but the different seams or layers of which the coal-bed is composed also vary in composition. Another difficulty in attempting to secure a sample truly representative of any mine is that the preparation of the coal by the miner, that is, the removal of impurities by the miner, is not uniformly well done. It is, therefore, impossible to consider a sample taken from a single car of coal as representative of the coal from any mine. I have frequently taken samples continuously, all day long, of the whole output of a mine, extending this perhaps to cover a number of consecutive days, in order to obtain samples that would be truly representative; but even if we take samples in this way and from every part of the mine, we still find that these samples as taken from day to day will not be identical. In some mines in Central Pennsylvania, working coals that at times yield a product that is pure enough for use in by-product ovens for coking without washing, it is often found that the pure coal is confined to certain parts of the mine, while other parts yield coal that is utterly unfit for such use.

It seems to me also that one of the difficulties in attempting to determine the clinkering or fusing temperature of any coal from a truly representative sample, will be found in the fact that if the impurities present consist largely of slate, bony coal, or pyritic material, that the effect of these is to produce clinkering in blotches upon the fire bed, each blotch or patch of clinker being formed by an excess of the impurity at a particular spot in the fire; that, in other words, coal as ordinarily mined and fired under boilers is not sufficiently uniform to produce uniform clinkering. It has generally been supposed, from the standpoint of the miner or producer of coal, that the iron pyrite present in our Eastern coals is the most objectionable clinkering constituent and that the quantity of iron pyrite can be determined approximately by the quantity of sulphur in the coal. This, however, has been found to be true in but a limited number of cases, because we frequently find that coal may have a large quantity of sulphur with but very little pyrite. The Second Geological Survey of Pennsylvania some years ago began a series of investigations to determine how much of the sulphur contained in coal was combined with iron as iron pyrite and how much was "organically combined sulphur," but this investigation was not extended to include all of our Pennsylvania coals. It did, however, furnish us with a complete demonstration that nearly all of our coals in the eastern part of the United States contain more sulphur than can be accounted for by the quantity of iron pyrites present in the coal. In some coals in the far West we find large percentages of sulphur, but only a very small quantity of iron; that is, an almost entire absence of pyrite, although the analyses may show as much as nine per cent. of sulphur in the coal.

of stoker with natural draught—there is the Murphy, the Detroit, and the Chain Grate, and the Rooney.

A MEMBER.—These results that you have shown, are they all comparable with the original samples of the coal?

MR. HUBLEY.—In regard to all the samples that we worked on, these samples were taken according to a standard method which goes with our coal specifications. It starts with 300 pounds on top of the car, taken according to an arbitrary method and reduced by crushing on a canvass to 75 pounds and put through a small crusher and a 10 mesh screen and riffles, and going through smaller riffles and over grinders with a 10 pound sample to a 60 mesh. We have a sampler at our new boiler plant which takes away absolutely the personal equation.

DR. H. M. CHANCE.—Was that one great sample?

MR. HUBLEY.—Well, we had three cars to each group. This was made of a two pound sample from each car and further reduced by riffles. As a rule the 2700° was specified. I have taken the arbitrary point at which the pellet collapsed to half its original height. In every coal I have tested, I find that at this point the ash is fusing at a very fast rate, and I have taken that arbitrarily and called it the fusing point, and incorporated it in the specification.

MR. F. C. FREEMAN.—I would like to ask Mr. Hubley if the ash from coal coming from the same mine but in different shipments would at each time show the same fusibility? Would the variation of fusibility be very great?

MR. HUBLEY.—In regard to that question, do you mean taking a sample from a different shipment?

MR. F. C. FREEMAN.—Supposedly from the same mine.

MR. HUBLEY.—We have found a variation from some mines. For instance, we differentiate between true ash and ash from the partings. Run of mine coal contains a good deal of coal from the partings. Some ash constituents would run high and others low in certain mines, especially in high fusing ashes. In other words, the fusibility of the true ash and "parting" ash will sometimes vary in a mine, therefore, the R. O. M. sample will be affected according to the variable percentage of "parting" ash contained in the R. O. M. sample.

DR. H. M. CHANCE.—Mr. Hubley's paper is intensely interesting because it treats the subject in a way that makes it clear to those of us who are not mechanical engineers. It is interesting to learn that even from the standpoint of one who has done a vast amount of experimental work in determining the fusing point of ash that determinations of practical value are difficult to obtain by laboratory experiment. It seems that perhaps the best way to learn the fusing point of the ash of any coal is to burn the coal as in practice under an ordinary boiler. Those who are familiar with the mining of coal know that it is impossible to get a sample that will accurately represent the output from any mine. The taking of a sample from a single car of coal can not be expected to represent the output of the colliery from which it comes for any day, part of a day, or any fixed time. Nearly all bituminous coal is now mined by machines, usually driven electrically, and it is hauled by electric locomotives, in trains con-

sisting of ten, twenty, or more mine cars, from the workings to the mouth of the mine, or to the bottom of the shaft. Each train of mine cars comes from a particular part of the mine and the coal of these cars is representative only of the part of the mine from which they come. When the cars composing this train are dumped, they may perhaps form the principal part or all of the load of a railroad car. As the coal may vary in quality in every room and in different parts of the mine it may have quite different characteristics; there being no uniformity of composition, it is evident that a sample to be representative must contain coal from all parts of the mine.

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Where the sulphur occurs combined with iron as pyrite, and this is in a segregated form and not uniformly distributed throughout the whole coal-bed, the output of any mine will vary materially in the quantity of pyrite in the coal as mined. Under such conditions some cars of coal may contain quite a large excess in the form of "sulphur balls," that is, nodules and lumps of pyrite, while other cars may be almost free from this objectionable constituent. This is one of the difficulties that the salesman finds in selling such coal. He may ship a car of coal that shows but little pyrite, while other shipments from the same mine may contain three or four per cent. of sulphur, and these variations are often beyond the power of the operating company to regulate.

Mr. F. Van Buren Connell.—I would like to ask what you consider the best specification for ordinary boiler practice in this section of the State, and whether it is best to state the point of fusibility?

Mr. Hubley.—As I said before, the specifications would depend entirely upon the nature of the load of the boiler plant. If you have a plant where 200 per cent. of rating is constantly required from a state of banked fires, you will reach a very high temperature, perhaps 2750° or 2800° from a forced draft. You will have to have a fuel that will fuse higher than this point. If you run about rating, your fuel bed temperature should not go above 2200° or 2300°, in which case the buying field is a very broad one. Non-uniformity of coal is another point to be considered. We have had coal from a number of shippers that would vary very slightly. Probably that would depend upon the nature of the mine, and the preparation of the fuel.

Mr. Connell.—Consider a plant where a high rating, say 200 per cent. overload is required sometimes; what would you consider a practical value to state in the specifications? Also considering it is difficult to get a low fusing point?

Mr. Hubley.—I would say 2700° or 2800° F., and at this figure I would say you would have no difficulty in finding Middle Pennsylvania fuel at $1.30 to $1.40 a ton at the mines. These coals with high fusing points naturally cost a little bit more money than the low fusing point coals.

Mr. E. B. Carter.—Have there been any successful experiments in raising the fusing point of the coal by the combination of fusible matter, such as crushed limestone or some form of shale?

Mr. Hubley.—Professor Marks, of Harvard University, has experimented for a number of years on this subject, and in 1910 he published a paper covering his results. He built a small furnace in his laboratory and burned coal at certain rates on regulation grates and certain fixed draft, and I believe he found some materials with which he could raise the fusing point of the ash sufficiently, but in general it was too expensive a process to use commercially. Crystalline silica was one of the things he mixed with the coal for this purpose, but the ordinary sea sand was too full of iron. He tried granulated oyster shells and other things, but none of them worked. That paper, I remember, was very interesting. Professor Marks is to deliver a paper on this subject next month before the A. S. M. E. in New York City.

Mr. E. B. Carter.—I would like to ask Mr. Hubley whether he has found the coals that run high in fusing points of ash, whether they are high volatile or low volatile coals?

Mr. Hubley.—As far as the Middle Pennsylvania coals are concerned, the high fusing ashes do not follow the lowest volatile matter, but the volatile ranges in my mind from 18 or 16 per cent. to 24. There is no particular law that I know of as far as the Pennsylvania fuel goes.

Mr. Carter.—Did you say 16 to 24 per cent?

Mr. Hubley.—Yes.

Mr. Carter.—That would not be up in the gas coals.

Mr. Hubley.—Gas coals apparently fuse at quite low temperature, that is, what few I have been able to experiment with, which were from the Fairmount District. I have only had experience with two or three of them.

Mr. C. H. Bigelow.—What method do you use for penalizing in coal specifications?

Mr. Hubley.—So far as we have been able to arrive at a way of penalizing, we simply fix on a minimum temperature at which fusion is to occur, and reject the coal which does not come up to this figure. I would like to hear any suggestions in regard to this. I have been casting around myself as to how this question should be handled. When you lower the fusing specification below 2600, as I said before, you should consider the viscosity.

THE EDISON AGGREGATE — *January, 1915*

Reproduction of a letter written by Mr. Thomas A. Edison to President W. S. Mallory of the Edison Portland Cement Company. It speaks for itself.

Cable Address "Edison, New York"

From the Laboratory of Thomas A. Edison,

Orange, N.J. Dec. 16, 1914.

Mallory:

A careful estimate by engineers of the damage to our concrete buildings shows that 87% are in good condition in spite of the intense heat occasioned by the highly inflammable nature of their contents.

The brick and steel buildings subjected to the fire were entirely destroyed as also were their mechanical contents; of the machinery in the concrete buildings about 85% can be used after slight repairs. I consider this a triumph for concrete considering the fact these buildings were among the first built in this country before up-to-date methods of reinforcing were used.

Edison

FIG. 1.

Paper No. 1147

REINFORCED CONCRETE IN THE EDISON FIRE

PERCY H. WILSON

Read January 2, 1915

Owing to the great prominence and distinction of Thomas A. Edison, the fire which destroyed a portion of the Edison Works at West Orange, New Jersey, on the evening of December 9, became a matter of national interest and importance. No recent event attracting like attention has been the subject of so many contradictory reports. As is usually the case, the engineering press exercised precaution not to exaggerate or overstate the facts, and gave to the public a correct report of the occurrence. As opposed to this, the daily newspapers and some trade journals published grossly exaggerated and misleading accounts of the fire. Furthermore, Mr. Edison's views upon the subject of insurance are not altogether in conformance with the opinions of many interested in that side of the question, and having erected this plant with the conviction that the reinforced concrete buildings comprising a large part of it were fireproof, there was, naturally, a disposition on the part of some to give undue emphasis to such damage as occurred in structures of that type, many reports stating that Mr. Edison's alleged "fireproof" concrete building had "burned." Some writers seemed to take pleasure in insisting that Mr. Edison was not infallible on the subject of fireproof construction, and that the real fireproof building has never been devised.

Immediately following the fire a careful engineering survey of the entire plant disclosed the fact that a little in excess of 87 per cent. of the reinforced concrete structures was in good order, and that furthermore, according to Mr. Edison's own statement, approximately 85 per cent. of the machinery could be salvaged. As early as January 5 manufacturing had resumed in one of the concrete buildings. Therefore, the fire and its results as they pertain to reinforced concrete are a matter of extreme importance to engineers, architects, owners of manufacturing plants, and insur-

ance interests. These interests are concerned not only with the resistance of reinforced concrete to fire, but with the cost of repairs, such as will be necessary to restore the damaged portions of the concrete buildings. Indeed, the entire subject is one of national importance, for, without question, the record of the Edison buildings points the way to a vast reduction in the fire losses of the United States, which now exceed, counting the maintenance of fire departments, four hundred and fifty millions per year. In brief, the remarkable resistance of these concrete buildings to an altogether unusual stress, due to the vast quantity of highly inflammable and heat-creating types of materials stored therein, bears out the record of reinforced concrete whenever subjected to fire. There is no case on record where a well constructed reinforced concrete building conforming to standard engineering practice has succumbed to fire, though, as in the case of the Edison fire, superficial damage may have resulted.

Wide publicity has been given to the statement made by Mr. Edison to the effect that had these buildings been fitted with window frames of metal and wire glass instead of the ordinary wooden sash and plain glass, the great loss sustained by him through the destruction of contents would have been prevented. This gives further emphasis to the need for protective measures of the character described. The buildings were in rather close proximity, and the flames rapidly passed from one structure to another. In other words, for the time being, these buildings were transformed into huge furnaces or stoves of reinforced concrete, the heat from burning wax, films, and materials of like heat-creating nature destroying here and there a concrete column or beam. In the main, however, the behavior of the buildings sustains the claim made in behalf of concrete, namely, that the contents of a concrete building will be entirely consumed before heat can penetrate the armor of concrete to the degree that vital or weight-carrying members will buckle or fail, resulting in the total collapse of the structure.

The theory of the low thermal conductivity or heat transmission of concrete, was first brought to public attention by Professor Ira H. Woolson, formerly of Columbia University, now Consulting Engineer to the National Board of Fire Underwriters. He demonstrated that results of tests with small specimens subjected to the heat of laboratory furnaces did not correspond with the

results shown when concrete in the form of columns, walls, and girders was subjected to fire. As stated, the contents of a structure were usually consumed before damage to the building resulted. Professor Woolson reported that the 4-inch walls of a cinder-concrete test chamber used by him had successfully withstood tests aggregating 20 hours at temperatures ranging from 1700 to 1900 degrees F., the walls being drenched while red hot with water at 60 pounds nozzle pressure. In tests of concrete panels conducted by the United States Geological Survey, 1700 degrees F. was applied for two hours without damage other than shallow surface disintegration. The backs of specimens, which were composed of broken beams previously used in testing, bore paper labels which were not even scorched and the reverse side could be touched by the hand without discomfort. As a matter of fact, we find no voluminous data relating to the fire-resisting properties of concrete, that is to say, as compared with investigations of its properties along other lines. This is due to the fact that there has been but a single story to tell concerning its behavior under stress of fire. Concrete buildings have never failed in the sense that other structures composed of non-combustible materials have collapsed.

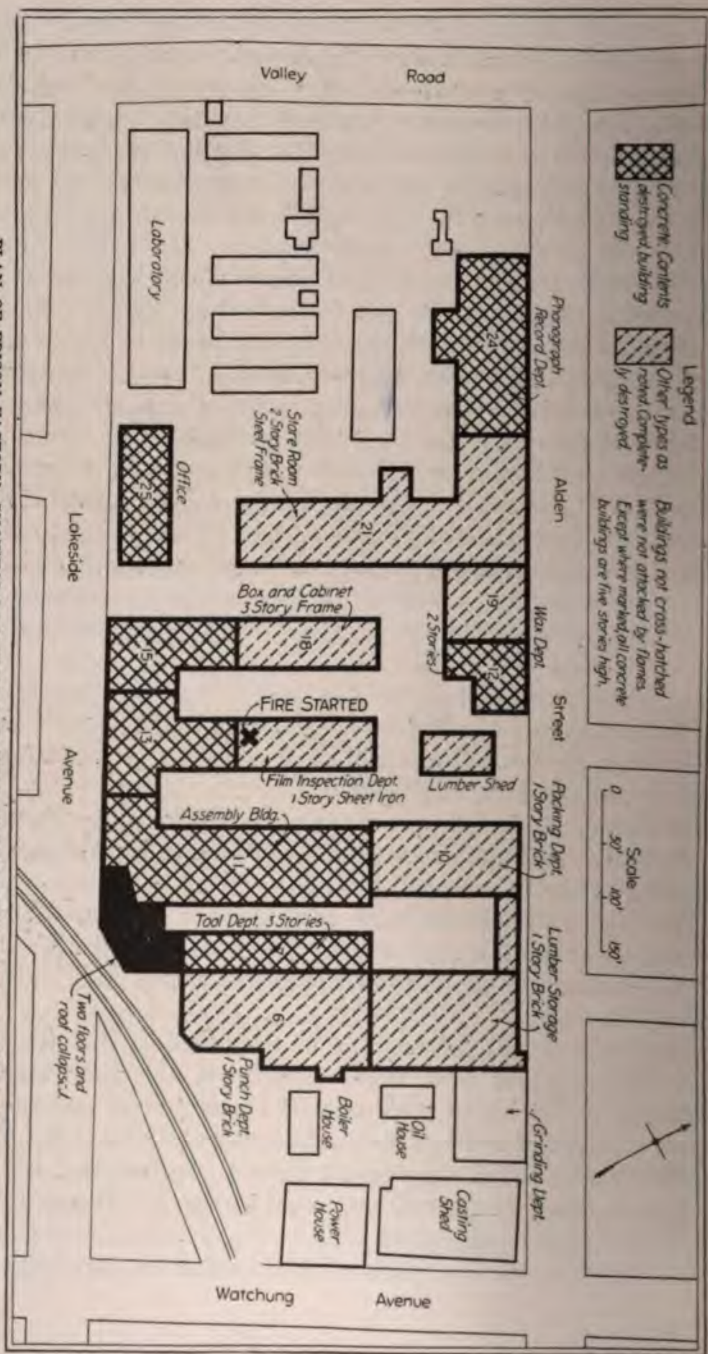
It is our purpose to present a series of slides illustrating the exact condition of the Edison buildings as they appeared immediately after the fire. There will be shown every point of failure as well as parts in good condition.

As stated, the fire broke out about 5 o'clock on the afternoon of December 9, and had practically run its course by 2 o'clock in the morning of the following day.

Fig. 1. In corroboration of some of our previous statements we will show first this letter from Mr. Edison to Mr. W. B. Mallory, President of the Edison Portland Cement Co. It requires no explanation.

Fig. 2 shows you the location of the buildings and the various materials of which they were constructed, the plant comprising buildings of brick and steel as well as reinforced concrete structures. We will first illustrate the progress of the fire.

The fire started in the one-story sheet iron building, which was part of building number 13 as shown in Fig. 2. It was supposed that a roll of moving picture films in this building ignited, but the actual cause of the fire has never been definitely determined.



PLAN OF EDISON FACTORY, SHOWING LOCATION AND TYPE OF BUILDINGS ATTACKED BY FIRE

FIG. 2.

FIG. 3.

FIG. 4.

A very brief period of time had elapsed before the fire spread to the building known as building number 24, shown in Fig. 3. As you will note this is a 5-story structure. It contained machinery used in sundry manufacturing processes and also a quantity of cylindrical and disc records, which are very inflammable and have great heat-creating properties. Fig. 4. These buildings are numbers 21 and 24, number 21 being of brick and structural steel and number 24 concrete.

Fig. 5.

Fig. 5. This is another view of concrete building number 24, in which the contents are being consumed. You will note the frames of the wooden window sash being rapidly consumed.

Fig. 6. Fig. 6 presents an interesting general view of the plant as it appeared at the expiration of the fire. We will now consider in detail the results of the fire.

Fig. 7. The pile of debris and section of brick wall standing between the tree and the reinforced concrete building are all that remain of what was formerly a 1-story brick structure, known as building number 10.

Fig. 6.

Fig. 7.

Fig. 8.

Fig. 8. This is a more extended view of the remains of this brick building.

Fig. 9.

Fig. 9. We will now consider the largest of the reinforced concrete buildings in the plant. This was known as building number 24. Fig. 9 shows the burned out structure. It stands in sharp contrast to the utterly demolished brick building shown in the preceding picture. This structure, however, did not escape all damage. On the contrary, at one or two points, it was seriously damaged, although these damages can be repaired. It was in this building that manufacturing was resumed on January 5. It was one of the buildings reported to have been "burned up."

Fig. 10.

Fig. 10 shows the most serious damage that occurred to the concrete building previously shown. This is a view taken on the third floor in which phonograph records were stored. The intense heat shattered a number of columns.

Fig. 11. In contrast to the columns shown in the preceding picture these columns withstood the test. They are on the fourth floor of the same building and are practically intact. Some idea of the degree of heat may be obtained by looking at the steel racks

Fig. 11.

shown on the right of the picture which have yielded under the test.

Here we have a striking exemplification of what is frequently said about concrete buildings, viz.: that a fire may occur in one part of the structure without damage to the building

Fig. 12.

Fig. 13.

or contents in other departments. Fig. 12 is a view of the first floor of the same building in which are stored wooden crates. All this construction, as well as the contents, were unharmed by the

Fig. 14

application of water and the fire was unable to gain access to this department.

Fig. 13 shows one shattered column and a sagging floor beam. This floor was stored with records and like combustible material.

Fig. 14. This is the general office building of the plant, known as number 25. At the left is shown the burned out portion of the building, while at the right the offices and contents on the lower floor were unharmed. The solid section shown in the center of the building is a line of concrete vaults.

Fig. 15.

Fig. 15. This is the second floor of the office building as it appeared after the rubbish and ashes had been removed. The window frames as shown were entirely consumed, but the concrete throughout is in good condition.

Fig. 16. The columns on the third floor of this building, known as number 15, were broken by the heat and the structure is shored at that point as shown on the picture. This is practically the sum total of damage sustained by this structure.

Fig. 16.

This building (Fig. 17) is one of the most convincing illustrations of the fire-resisting properties of concrete. Within it tons of wax were stored, the building being known as number 12.

Fig. 17.

800238

FIG. 18.

Considering the intense heat generated by the burning of this substance it was, as stated by *Engineering Record*, a marvel that the structure did not collapse. You will note the good condition of the structure shown in this view.

FIG. 19.

Fig. 18. Another view of the "wax" building and further proof of its remarkable behavior.

Fig. 20.

Fig. 19. Here are the ruins of demolished structures of brick and steel as shown in the foreground. The concrete buildings in the background, reading from left to right, are buildings 13 and

15, and at the extreme right is the office building. In looking at the two concrete buildings at the left, the position of buildings

FIG. 21.

formerly adjoining them is indicated on the fire blackened walls. Their faint impressions against the concrete might well be termed the ghosts of formerly substantial but non-fireproof buildings.

Fig. 22.

Fig. 20 is a view of the third floor in concrete building number 7. The mass of junk in the foreground and extending to the rear is the remains of the sheet iron japanning ovens.

Fig. 21 shows a plastered concrete column on the second floor of concrete building number 7.

Fig. 23.

Fig. 22. The structure at the right is concrete building number 11 and at the left are the remains of a brick building known as number 10.

Fig. 24.

Fig. 23 shows the ground floor of concrete building number 11, in which was stored an immense quantity of wood

used in cabinet work. It also contained finished talking machines ready for shipment. The intense heat that occurred here caused a number of the columns to spall as shown in the picture, but they are not as badly damaged as would appear and they are now being repaired. These repairs are made in a very simple manner by casting about the columns a layer of new concrete reinforced with spiral rods. This will transform them from square to circular shape.

Fig. 24 is typical of the damage done to some of the columns where the heat was unusually intense and, again, it is not as serious as would appear upon superficial observation. This column, like those previously described, can be restored at small cost.

Fig. 25.

Fig. 25. In this building, number 11, the columns, as shown, were seriously damaged. This picture also serves as a notable example of the strength of reinforced concrete, for it will be noted that upon the surviving column at the extreme right, which is practically intact, has been thrust an immense weight, which it is sustaining in the manner shown.

Fig. 26. This is a closer view of one of the columns shown in the preceding view, the one which sustained the most damage.

Fig. 26.

We now come to a picture (Fig. 27) which is interesting in many respects. This view was the one selected by all the

opponents of concrete as best suited to bolster up their arguments that it is a failure when subjected to fire. The structure shown is an L, a small part of the large reinforced concrete buildings known as 7 and 11. The two upper floors, which were heavily loaded, collapsed, together with the roof, the mass descending with terrific impact upon a lower floor which sustained the great burden as indicated in the picture. The pictures published gave the impression that this L was a large structure in itself and they were sent broadcast as an example of the danger of using reinforced concrete for structural purposes.

Fig. 27.

As stated at the outset, the damage to the concrete buildings, which we have shown without fear or favor, comprises an extremely small percentage of the total concrete construction represented by these seven large structures. The fact that manufacturing has resumed and repairs are under way is in marked contrast to what usually occurs when buildings of other types are subjected to like tests. In a majority of cases structures passing through an ordeal of this character must be taken down, whereas not a single one of the concrete buildings will be razed. That this type of structure has the confidence of Mr. Edison is shown by

the fact that all important new buildings erected on the site will be of reinforced concrete. Had it not been for the presence of wooden window sash and plain glass there is every likelihood that the contents of many of the concrete buildings would not have become ignited.

In conclusion we will refer as briefly as possible to three notable examples of the fire resistance of concrete corresponding to the behavior of the Edison buildings. Fig. 28 shows the concrete store house of the Naumkeag Steam Cotton Com-

Fig. 28.

pany, which passed through the Salem fire, giving it for the time being national distinction among engineers and insurance companies. The Manufacturers' Mutual Fire Insurance Company, of Providence, R. I., in a report on the above building, said:

"This building, although surrounded on all sides by a sea of flames, came through the fire practically uninjured. It is a most instructive object lesson as to the feasibility of building storehouses at moderate cost that will withstand the fiercest conflagration."

In Philadelphia some years ago, the concrete building of the F. W. Tunnell Company, manufacturers of glue, was subjected to fire and repair costs were a mere pittance, amounting to about

$15. Insurance adjusters made their estimates of damage at a meeting held in this building the day after the fire which destroyed the rest of the plant.

Another notable concrete building tested by fire was that of the Dayton Motor Car Company, Dayton, Ohio. The heat became so intense as to melt down brass machinery parts, but the damage to the building was so slight that within two days after the fire occurred manufacturing operations were resumed throughout the structure.

ABSTRACT OF MINUTES OF THE BOARD OF GOVERNORS

Regular Meeting, October 13, 1914

Present: President Swaab, Vice Presidents Mebus, Snook, and Vogleson, Directors Berry, Furber, Gibson, Hibbs, Andrews, Dauner, Dunlap, Moore, the Secretary, and the Treasurer.

The minutes of the Regular Meeting of September 15th were read and approved.

The Treasurer reported a net loss of $19.64, as compared to a net gain of $2493.99 for the same period of last year.

The report of the Membership Committee was presented and the following were elected to membership: Active, Carl R. Camp, Andrew J. McCrudden; Associate, Clarence M. Foster; Junior, L. Herbert Forstner, Horace G. Leng.

The House Committee was authorized to provide entertainment for the balance of the year, and a sum not exceeding $100 was appropriated for this purpose.

The Secretary was authorized to negotiate an exchange of privileges with the Detroit Engineering Society.

The question of water supply to the third and fourth floors was referred to a Committee, consisting of Messrs. J. E. Gibson, F. C. Dunlap, and F. K. Worley, said Committee to report at the next meeting of the Board.

Special Meeting, October 17, 1914

(To receive the report of the Committee on Public Relations relative to licensing or registration of engineers of the State of Pennsylvania.)

Present: President Swaab, Vice President Mebus, Directors Hibbs, Furber, Wagner, Dauner, Haldeman, Yarnall, Gibson, the Secretary, and the Treasurer.

The report of the Public Relations Committee upon the matter of the licensing and registration of engineers was presented, and it was moved and carried that the report be accepted by the Board.

Regular Meeting, November 17, 1914

Present: President Swaab, Vice Presidents Vogleson and Snook, Directors Andrews, Haldeman, Dauner, Worley, Hibbs, Berry, Dunlap, Yarnall, Wagner, and the Secretary. Messrs. Mebus, Gibson, Moore, and Bailey were excused.

It was moved and carried that a vote of sympathy be extended to Mr. Mebus on account of the bereavement suddenly thrust upon his family.

Reports of the Secretary and Treasurer were presented and laid over until the December meeting for action.

The House Committee's report was presented and approved. The Membership Committee's report was presented and the following elected: To Active Membership, M. Taylor Calef and Frank Shuman; to Junior Membership, Edwin vonK. Borchard.

The Special Committee on water supply in the Club-house reported progress.

Communication from the Pennsylvania Welfare Conference was presented and tabled.

Communication from the American Road Builders' Association, asking for delegates to the Convention in Chicago December 14th to 17th was referred to the President, with power to appoint such delegates.

A report from Richard Gilpin, relative to elevator safety devices, was presented and Secretary instructed to acknowledge the report and thank him for his services.

Communication from the Chairman and Secretary of the Committee representing the Engineering and allied Scientific Societies which held a meeting May 15th, 1914, regarding a meeting of the societies in the year 1915, was presented, and the President appointed J. A. Vogleson, D. Robert Yarnall, and J. H. M. Andrews to confer with them on this subject.

Communication from Harry Wickland was presented and his resignation accepted as of July 1, 1913, and the Treasurer authorized to strike the remaining account from the books.

Mr. Yarnall reported for the Committee on the Co-operative Movement, and, after discussion, which was participated in by Messrs. Swaab, Vogleson, Snook, Andrews, Haldeman, Dauner, Worley, Hibbs, Berry, Dunlap, Yarnall, Wagner, and McMillan, the following resolution was passed:

"That the report of the Executive Committee on Co-operation be provisionally accepted and referred back to the Committee with a view to having such changes made as may seem advisable, to be then referred back to this Board for final consideration."

Regular Meeting, December 15, 1914

Present: President Swaab, Vice Presidents Vogleson and Mebus, Directors Berry, Furber, Yarnall, Gibson, Wagner, Andrews, Dauner, Dunlap, and the Secretary.

Mr. Fred W. Abbott addressed the Board regarding the acquirement of the property at the northwest corner of Sixteenth and Walnut Streets for Club-house purposes. After the presentation of the subject by Mr. Abbott, the President appointed a Committee, consisting of Messrs. Furber, Wagner, and Worley, to confer with Mr. Abbott further in the matter.

The Secretary presented a list of resignations and the following were accepted as of December 31, 1914: Herman E. Beyer, James G. Biddle, William F. Carson, Charles Henry Davis, Owen B. Evans, H. M. Fetter, Henry Franz, James F. Haldeman, Robert A. Hentz, A. Morris Herkness, H. D. Hess, Edward Hoopes, J. E. Hubbell, Karl Nibecker, Richard C. McCall, W. H. Pavitt, Jr., G. W. Philips, William T. Price, F. H. Stewart, J. W. Thompson, Alexander Wilson, 3d, Howard M. Yeager, R. W. Yerkes, E. H. Zieber.

The resignation of C. W. T. Barker was accepted as of July 1, 1914, and the resignations of Barclay White and Charles M. Mills were accepted as of December 31, 1913.

The Treasurer presented a list of members to be dropped, in accordance with the By-Laws, and this list was referred back to the Treasurer and Business Manager, to make further efforts to collect the delinquent accounts.

The Membership Committee presented its report and the following were elected: To Active Membership, O. H. Gentner, Jr., Aurin B. Nichols, Harold Pender, and Percy F. Proctor; to Associate Membership, Edward Lupton; to Junior Membership, Alexander Broadhead, Leonard B. Gallagher, and John B. Shallcross.

The following Juniors were transferred to Active Membership: W. Neilson Edwards, Howard H. Demmert, Charles W. G. Haydock, H. Lawrence Hess, Boyle Irwin, Jr., T. Otto Mayer, Thomas M. Chance, Charles E. Hubsch.

David Thompson was transferred from Junior to Associate Membership.

Mr. Yarnall reported for the Co-operative Committee and the Board adopted the report of the Committee and favorably recommended the proposed Charter and By-Laws of the Engineers' Society of Philadelphia to the Club.

The following letter from W. Nelson L. West, regarding second mortgage bonds, was ordered to be spread upon the minutes:

MR. D. ROBERT YARNALL,
Chestnut Hill, Philadelphia.

Dear Sir—In reply to yours of the second, I beg to advise that the proposed change in the By-Laws and Charter of the Engineers' Club can have no possible effect on the outstanding bonds and other obligations of the Club.

Very truly yours,

(Signed) W. NELSON L. WEST.

REGULAR MEETING, JANUARY 14, 1915

Present: President Swaab, Vice President Vogleson, Directors Haldeman, Yarnall, Gibson, Hibbs, Worley, Andrews, Moore, and the Secretary.

The minutes of the Regular Meeting of December 15th were read and approved.

The Secretary presented a list of resignations which had been received since the December Board meeting, and these were referred to the incoming Board for action.

The Treasurer reported a net loss of $747.07, as compared to a net gain of $2671.41 for the year 1913.

Reports were presented from the House Committee and Co-operative Committee.

The Membership Committee's report was presented and the following elected: To Associate Membership, Harry F. Sieber; to Junior Membership, James B. Cutler, Ira F. Fuhrmann, William M. Moody, Frank J. Sepas.

The Business Manager's report was read and approved.

Communications were received from Harold Pender, Carl Hering, and Lesley Ashburner, which were referred to the incoming Board for action.

E. B. Callow was placed on the non-resident membership list as of January 1, 1914, and the Treasurer authorized to strike the excess dues from the books.

The death of Captain St. George H. Cooke was announced, and the President appointed Messrs. Andrews and Worley to prepare a Memorial for publication in the Proceedings.

ABSTRACT OF MINUTES OF THE CLUB

Regular Meeting, October 3, 1914

The meeting was called to order at 8:35 p. m. by President Swaab, with 72 members and visitors in attendance.

Henry Leffmann presented the paper of the evening, entitled "The Water Supply of Ancient Jerusalem," which was discussed by Messrs. Trautwine, Swaab, Watters, Leffmann, and others.

Regular Meeting, October 17, 1914

The meeting was called to order by President Swaab at 8:30 p. m., with 72 members and visitors in attendance.

The Secretary announced that Messrs. Carl R. Camp and Andrew J. McCrudden had been elected to Active Membership, Clarence M. Foster to Associate Membership, and L. Herbert Forstner and Horace G. Leng to Junior Membership.

Mr. D. Robert Yarnall presented the following resolution:

Resolved, That it is the opinion of the Engineers' Club of Philadelphia that legislation on the subject of licensing engineers is unnecessary and undesirable.

The President announced that a Special Meeting of the Club would be held on Tuesday, October 27, 1914, at 8 p. m., to discuss this resolution and also the legislation which caused the introduction of the resolution.

Mr. J. Irvine Lyle, General Manager of the Carrier Air Conditioning Company, presented the paper of the evening, entitled, "Air Conditioning," which was discussed by Messrs. Cassell, Miller, Mensing, Trautwine, and others.

At the conclusion, a unanimous vote of thanks was tendered Mr. Lyle.

Special Business Meeting, October 27, 1914

Meeting was called to order by President Swaab at 8:40 p. m., with 38 members in attendance.

After discussion, the following resolution was moved and carried:

"It is the sense of this meeting that the licensing of Engineers is undesirable and unnecessary, and, further, that this meeting endorses the principles embodied in the Report of the Public Relations Committee of the Engineers' Club of Philadelphia, and the supplementary report of October 26, 1914, submitted by the Philadelphia Association of Members of the American Association of Civil Engineers, said principles being in accord with a resolution adopted by the Club on December 9, 1911, urging the creation of a State Department of Public Works.

"And further, That this meeting expresses its cordial approbation of the procedure adopted by the Engineers' Commission in relation to the Proposed Act of Licensing Engineers, and expresses the hope that the same method of procedure be followed also in connection with any future legislation affecting that and similar interests."

Joint Meeting, November 7, 1914

Of the Illuminating Engineering Society and the Engineers' Club of Philadelphia.

The meeting was called to order by President Swaab at 8:40 p. m., with 63 members and visitors in attendance.

The Secretary read the minutes of the special business meeting held Tuesday, October 27, 1914, which were approved as read.

Dr. Herbert E. Ives presented the paper of the evening entitled "Physical Photometry," which was discussed by Messrs. Hess, Temple, Nicholas, Feree, Bond, and Drs. Crampton and Hering.

Business Meeting, November 21, 1914

Meeting was called to order by President Swaab at 8:30 p. m., with 49 members in attendance.

The Committee on Nominations presented the list of candidates for offices for 1915: President, James Mapes Dodge; Vice President, D. Robert Yarnall; Secretary, Lewis H. Kenney; Treasurer, J. Reese Bailey; Directors, Charles E. Bonine, Wm. M. Irish, Jonathan Jones, J. Chester Wilson.

The Secretary announced that the Board of Governors, at their meeting held November 17th, had elected to membership the following: Active Membership, M. Taylor Calef, Frank Shuman; Junior Membership, Edwin vonK. Borchard.

Joint Meeting, November 21, 1914

Of the American Society of Mechanical Engineers, Philadelphia Section, and the Engineers' Club.

Meeting was called to order by President Swaab at 8:35 p. m., with 112 members and visitors in attendance. Prof. H. E. Ehlers, chairman of the Philadelphia Section of the American Society of Mechanical Engineers, then took the chair and introduced the speaker of the evening, Mr. F. C. Hubley, who presented a paper entitled "Bituminous Coals: Predetermination of their Clinkering Action by Laboratory Tests."

Messrs. A. C. Wood, Robert H. Fernald, J. E. Fulweiler, E. M. Nichols, Charles H. Bigelow, H. M. Chance, Emmett B. Carter, Carl Hering, and others discussed the paper.

Joint Meeting, December 5, 1914

Of the American Chemical Society, Philadelphia Chapter, and the Engineers' Club.

Meeting was called to order by President Swaab at 8:40 p. m., with 163 members and visitors in attendance.

Dr. S. W. Stratton, Director, Bureau of Standards, Washington, D. C., addressed the meeting on, "The Bureau of Standards and Its Relation to the Industries."

The proposed charter and by-laws of the Engineers' Society of Philadelphia were presented and explained by Mr. W. P. Taylor. Prof. Edgar Marburg also made some remarks upon the subject and the President ordered that they be brought up for formal discussion at the next meeting of the Club, December 19, 1914.

BUSINESS MEETING, DECEMBER 19, 1914

Meeting was called to order by President Swaab at 8:15 p. m. with 87 members in attendance. Secretary announced that the Board of Governors at their Meeting, December 15, 1914, had elected the following new members: Active Membership, O. H. Gentner, Jr., Aurin B. Nichols, Harold Pender, Percy F. Proctor; Associate Membership, Edward Lupton; Junior Membership, Alexander Broadhead, Leonard B. Gallagher, John B. Shallcross.

In accordance with Art. V., Sec. 2, of the By-Laws, the name of Mr. J. W. Ledoux was presented as a candidate for President. The official list is now as follows: President, J. W. Ledoux; Vice President, D. Robert Yarnall; Secretary, L. H. Kenney; Treasurer, J. Reese Bailey; Directors, Charles E. Bonine, William Irish, Jonathan Jones, and J. Chester Wilson.

The Proposed Charter and By-Laws of the Engineers' Society of Philadelphia were presented for discussion by Mr. D. Robert Yarnall, Chairman of the Executive Committee of the Engineering Cooperative Movement, and explained by Mr. Henry Hess.

After discussion the following resolutions was introduced by Mr. W. P. Taylor, seconded by Mr. W. C. L. Eglin, and unanimously carried.

Resolved, That the Engineers' Club of Philadelphia endorses the proposed Charter and By-Laws prepared by the Executive Committee of the Engineering Co-operative Movement.

JOINT MEETING, DECEMBER 19, 1914

Of the American Institute of Electrical Engineers and the Engineers' Club.

Meeting was called to order by President Swaab at 8:45 p. m. with 153 members and visitors in attendance.

Dr. Wm. L. R. Emmett presented the paper of the evening entitled, "Mercury Turbine," which was discussed by Messrs. H. E. Ehlers, Henry Hess, E. M. Nichols, Carl Hering, W. C. L. Eglin, and John C. Trautwine, Jr.

A unanimous vote of thanks was tendered Dr. Emmett.

JOINT MEETING, JANUARY 2, 1915

Of the American Society of Marine Draftsmen, Delaware River Branch, and the Engineers' Club of Philadelphia.

Meeting was called to order by President Swaab at 8:40 p. m., with 53 members and visitors in attendance.

The scheduled speaker of the evening, Mr. John F. Metten, Chief Engineer, Cramps Ship and Engine Building Co., was unable to be present.

Dr. Henry Leffmann addressed the Club on "The Garden of Eden" using the first chapter of Genesis as the basis of his talk.

Mr. Percy H. Wilson, Secretary of the American Society of Cement Manufacturers, spoke on the recent fire in the Edison laboratories. Mr. Wilson showed many pictures of the progress of the fire and its effects on the building.

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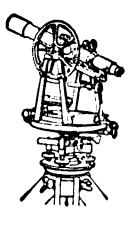

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NOTE—The Club, as a body, is not responsible for the statements and opinions advanced in its publications.

Vol. XXXII APRIL, 1915. No. 2

PAPER NO. 1148

PRESIDENTIAL ADDRESS

THE FUNDAMENTAL ELEMENTS ENTERING INTO THE MAKEUP OF THE MODERN CITY AND A PLEA FOR A SMALLER CITY

S. M. SWAAB

Annual Meeting February 6, 1915.

INTRODUCTION

The elements entering into the makeup of the modern city are so diverse in character and so numerous as to preclude the idea of more than a passing reference to many of them. Certain of the more important elements are treated in some detail, but it is manifestly impossible, in a paper of this kind, to go exhaustively into any of them. The paper, therefore, should be considered not in the light of a treatise on any of these elements, but rather as a presentation of the principal facts connected with the most important of them. The consideration of the subject from the politico-economical, administrative, financial and the purely sociological aspects of the problem, although fundamental in character and sec-

ond to none in importance, has not been attempted; because it is intended to treat herein only of the so-called engineering elements.

The order in which the various subjects are treated in this paper is as follows:

INTRODUCTION.

STREET PLANNING.
TRANSIT.
WATER.
  Water Supply.
  Purification and Distribution.
SEWERAGE.
  Sewerage.
  Sewage Purification and Disposal.
SANITATION AND HOUSING.
STREET AND ROADWAY PAVING.
MISCELLANEOUS.

CONCLUSION—A plea for a smaller city.

It is not to be considered that the order in which these subjects are set down here represent the order of their importance in the makeup of the Modern City, but merely a convenient arrangement. The determination of the relative importance of these numerous topics would be a much more difficult subject than would appear at first sight; for instance, many cities have come into being without first having had prepared a definite plan of development. There is no doubt that many cities survive without proper transit facilities, but there is no doubt also and the connection can be shown that there exists a considerable amount of interdependence between the street plan and transit which should not be overlooked. Without an ample supply of water of a good quality no community could long exist and prosper, although certain cities, as Philadelphia, for instance, prior to the installation of its excellent water purification plant, have long survived the inroads of typhoid fever and other intestinal diseases, most of it traceable to this origin, by reason of the immunization of the inhabitants by long and continued use; and it goes without saying that without adequate sewerage as a counterpart of a good and sufficient water supply, we would still be subject to the depopulating effects of epidemic diseases which were not unusual prior to the discovery of the germ theory. Many

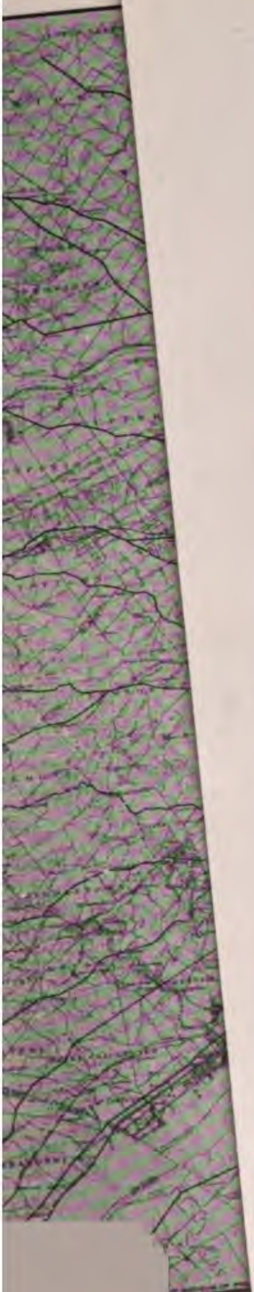

Fig. 2.—Radial road

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of the fundamental principles of sanitation are as old as the Mosaic Law and the principles of isolation and disinfection were known and practiced after the promulgation of that Code; and the method of the disposal of organic wastes, which is no doubt the prototype of the modern earth closet, is set forth clearly in Deuteronomy.

The Modern City is the resultant of a number of conflicting developments and can reasonably be compared with the human organism, with its skeleton, the city streets, and its water distributing pipes and sewers, the arteries and veins. Through the arteries, so-called, courses the water which is the life blood of the community, and through the so-called veins, the sewers, passes off the liquid matters contaminated in the processes of the bodily functions. To carry the simile further, were I an anatomist I might make a comparison of the heart and the water works pumping plant, and the kidneys and the sewage disposal system; suffice it to say the man-made organism, if it may be so termed, is quite as complex as is that with which the comparison has been made.

The City Plan

City Planning is a much overworked figure of speech, and is a term of rather recent origin, and, like so many terms of a general nature, is a misnomer. It has been satisfactorily established that long before the beginning of the Christian Era, many of the cities of ancient Greece, Rome, and Egypt were built according to a prescribed plan. Cities are, however, not *generally* planned in advance, but grow like any other organism, and in the course of events often undergo material changes. So material are these changes at times that entire cities are often re-planned, and as a result are reconstructed and rebuilt, or parts of cities are so modified as to make them almost unrecognizable to one who was well acquainted with the former layout.

What is recognized as the most essential feature of city planning is to lay down a comprehensive scheme which is capable of extension and elaboration, and which can direct or at least suggest the direction in which future extensions can be made, rather than to have these extensions made in the haphazard way as of yore, and and also to predetermine, considering the natural advantages of the site, the locations best fitted for the industries, for residence purposes, for business purposes, for commercial purposes and for communal purposes; and, last but not least, to provide those areas

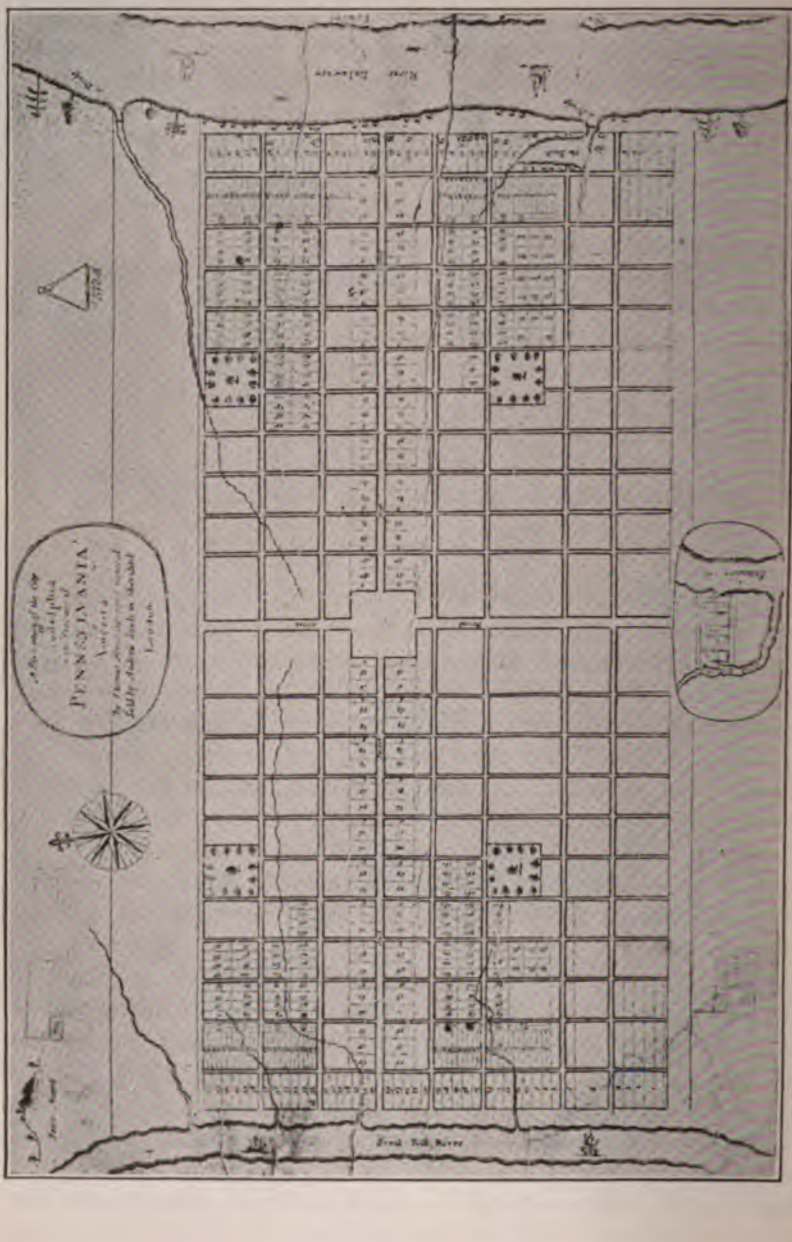

FIG. 3.—Holmes Map of Philadelphia. The modern gridiron.

usually designated breathing spaces, which are alike essential for recreation and for the general physical advancement and well being of the community. The natural tendency in the growth of communities has been to spread out from the origin, and where several of these have combined to form a city, the streets must provide intercommunication between the different established centers.

FIG. 4.—Alexandria, 323 B. C. Rectangular street system typical of practically all of the ancient cities of the Egyptians, Greeks, and Romans. The genesis of the gridiron.

STREET PLANNING

The street plan should, to be economical, conform to the topography, and the general lines of the streets should be as simple as possible, consistent with the uses to which it is proposed that they be put. Various schemes or systems of street layout as the radial and circumferential, the rectangular (commonly called the gridiron plan), etc., and combinations of these have been suggested, and in some instances schemes, resembling wholly or in part the lines of the cities of mediaeval Europe, the walls of which, when demolished, were replaced with what is commonly known as the Ringstrasse,

have been proposed, and in many instances the street lines are made to conform solely to the property lines, and many street lines are wholly dictated by accident.

FIG. 5.—Philadelphia, 1796. Shows natural crescent shaped or radial growth from water front, center at Market Street. This growth should have suggested radial streets to the early city planners.

Vitruvius, who lived in the time of Augustus, in his ten books on Architecture, directs that the streets should be so oriented as to lie in planes between the prevailing winds, of which he says there

are eight in all. They will be properly laid out if foresight is employed to exclude the winds from the alleys. Cold winds are disagreeable, hot winds enervating and moist winds unhealthy. As a matter of fact, in the ancient cities of which we have record, the principal streets occupied a generally north and south direction.

Perhaps it is necessary at this juncture to say something of the artistic in this connection. It is well known that the monotony produced by formal layout of city streets, flanked by row houses, so common in American cities, must needs have a depressing effect on the morale of the citizenry, and that a far healthier atmosphere is produced if, in designing even such a formal thing as a city plat, utility is taken to be not the sole but, rather, the central consideration. In the language of a prominent writer on this subject, "The planner should recognize that it is his function to find artistic expression for the requirements and tendencies of the place, and that he is not to impose upon it any preconceived ideas of his own."

As the streets furnish the means of access between the different parts of a city, and as the extent of a modern city is largely determined by the time which is required in transit between the business, generally the central district, and the outlying or residence districts, it is readily seen that just as soon as the city begins to assume any magnitude, the transit problem and the street layout become interdependent and one cannot be considered to the exclusion of the other. The transportation arrangements should be devised to provide adequate service, for the growth of the community depends upon convenient intercommunication between all its parts. Moreover, in the matter of the design of the streets themselves, straight lines are necessary for economy and curved lines for beauty, and generally a happy medium can be attained, whereby both ends will be met. In the districts, however, which it is proposed to devote to commercial purposes, straight lines may best serve the purposes of a proper and economical division of the land, and this will usually determine the lines of the streets. The proper apportionment of the land into that required for building purposes and that required for streets will usually be determined by practical considerations, having in view the necessities of each individual case. The proper subdivision of the street surface itself into roadway and sidewalk will also be influenced by the use to which it is proposed to put the street, and when considered in the light of recent experience where rapid transit facilities were not considered when the streets

were planned, the space allotted to the sidewalk should be ample to allow of the placing of such structures on the curb line as can not

FIG. 6.—Berlin, 1685, a remnant of the feudal type of city plan at the time of the founding of Philadelphia.

properly be placed elsewhere, if this condition is at all considered tenable. This is not to be construed as sanctioning the placing of kiosks or head houses over subway entrances, or any structures

FIG. 7.—Philadelphia

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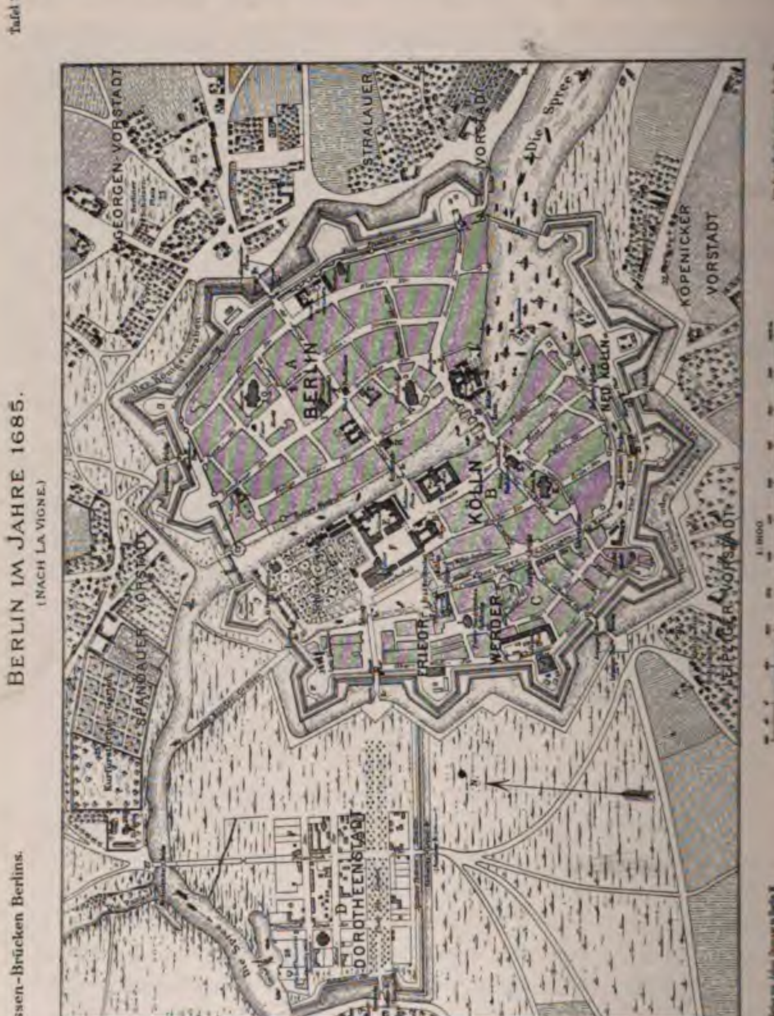

FIG. 6.—Berlin, 1685, a remnant of the feudal type of city plan at the time of the founding of Philadelphia.

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Fig. 7.—Philadelphia

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which form permanent obstructions to pedestrian traffic by decreasing the sidewalk width at a given place, and thereby producing a congestion of traffic rather than affording every means of dispersion and transit which is the function of a properly proportioned sidewalk. The grades of the streets for economy of construction will of course be such as will allow of the equable disposal of the material of excavation, or, to use a commonplace expression, to provide the necessary materials for making the fills from the adjacent excavations. Maximum grades, however, are recognized for use in connection with the different types of pavement, and for streets used for commercial purposes, the main arteries of traffic, the grades should be a minimum, consistent with the density and weight of the traffic and with the type of pavement used, and should probably in no case exceed 3 per cent.

The Width of the Street

The proper distribution of the main arteries of traffic and of the intermediate streets is a problem of no mean proportion, and here again the economical property subdivision enters to a large extent, as does also the direction and extent of the existing principal roadways, even if they originally followed a cow path. City planners who have studied the street problem extensively have adopted certain standard street widths for streets adapted for different purposes, but the standardization itself is questionable unless it is intended merely as a guide. For instance, we know by experience that the minimum width of main traffic streets in large cities should seldom be less than 125 feet between the houses, and in the same way probably the minimum width of residential streets should not be less than 55 feet, unless certain building restrictions require that the buildings be built back of the established line. That different widths of street should be chosen for projected streets in districts allotted to different purposes is self evident. Main traffic streets should evidently be widest and streets on which it is proposed to build medium sized houses for use as residences or cheap apartments can well be narrowest, and between these there can be all gradations. The main traffic streets in a city may provide ample surface for two lines of surface car tracks, in addition to providing sufficient room for pedestrian, wagon and motor traffic. On these streets may also be placed such structures to facilitate transportation as subways or elevated railroads, and it may be

well to occupy the center of the streets at the outset, with lawn areas with trees and shrubs, which can be used eventually to mask the elevated railroad structures where they are used, as in Paris and Berlin. Since the advent of the motor truck, an increased width has become necessary, as these latter conveyances require considerably more room to operate than is required to accommodate wagon traffic. Certain streets which will be used for residence and other purposes, but which do not, at the outset, warrant the expenditure of large sums of money, can be built on the principle of occupying the center of the street with the roadway paving and planting the sides in lawn spaces, which can be encroached on and used as an extension of the paved areas when the traffic warrants it.

Limitation of Height of Buildings

Notwithstanding the fact of the monumental character of certain high buildings, it cannot be disputed that such buildings, especially when built in close proximity to one another, interfere with the proper circulation of the air, obscure the sunlight and prevent its proper dissipation, and transform the streets into windy canyons and gloomy passageways and, last but not least, seriously interfere with the traffic on the surface by housing in a restricted area comparatively great populations which would otherwise be spread out over a much bigger area. Property owners take the position that while the limitations of their property as to length and breadth are clearly set forth in their deeds, the third dimension extends skyward at their discretion. This is a problem of serious concern for every large municipality, and this limit should be fixed by law.

The reason London has not built high buildings is because of the "Law of Ancient Lights." A house which has sunlight at any time must continue to have unrestricted sunlight to the end.

Transit

It is not required in a paper of this character to more than refer to the principal and usual methods of transit in modern cities. The development of the City during the last generation has been brought about principally through the agency of Rapid Transit, the usual transit facilities being supplemented in the vertical plane by the high speed passenger elevator operating in the high buildings, without which this type of building would be impossible.

FIG. 8.—Map of Budapest; illustrating the system of radial and circumferential thoroughfares as actually existing in a progressive city.

Whether passengers should be carried under-ground and freight on the surface or the reverse is a much discussed subject. True, it if that one phase of this subject which has not been given sufficient consideration and which has been too often entirely overlooked, is that an adequate system of underground transportation and distribution of goods may be quite important in relieving congestion on the street surface. The carrying of freight underground requires that the principal lines of traffic be laid out in conjunction with and

Fig. 9.—Christmas crowd on Market Street during subway construction.

with due consideration for the location of the freight terminals of the railroads entering the City.

Surface car lines are at present operated by underground or overhead trolley. Trolley poles should be placed if possible, on the party lines between the properties and directly on the house line, or as near thereto as is physically possible, or, preferably, the cross wires should, by arrangement with the property owners, be fastened in the front walls of the houses at the party line, thus doing away with the trolley poles altogether, and if properly insulated, should not unnecessarily increase the fire hazard. Consideration should be given the gauge of the tracks, for, under certain conditions, connec-

Fig. 10.—Two track subway, Market Street, Philadelphia.

Fig. 11.—Four track subway, Market Street, Philadelphia.

tions may be made with suburban lines, so as to handle through traffic, and on streets where two lines of rails are laid for car lines operating in opposite directions, with a limited clear space between the two tracks, it is a question whether it is best to place these two tracks so close together as to preclude the idea of using the space between them as a refuge for pedestrians, or whether they should be separated sufficiently so that it is known they can be used by pedestrians, in which case there is always more or less danger of accident. When surface traffic becomes congested, recourse is usually had to one or another of the types of overhead or underground construction with which we are acquainted. The overhead railroad or elevated as it is generally known has much to commend it, and structures of this type have been built which are not unsightly and which are relatively noiseless, and which, if placed on a street of reasonable width, do not unduly obstruct the light and air and which, while having all of the advantages of other structures, have few of the disadvantages possessed by some of them. Of course, the effect of the construction of an elevated railroad on the value of abutting property has to be given consideration, as has also the fact that while the cost of operation and maintenance is practically the same as compared with the operating cost of a subway, the cost of construction is considerably less, so much so that usually from three to five miles of elevated structure can be built for the cost of one mile of subway.

How far apart parallel surface transportation lines should be is a question which cannot be answered offhand. There is little doubt, however, that they should be sufficiently close together so that the walking distance is not so great as to be burdensome, and it is a fact that about a quarter of a mile seems to be about the distance which people will walk regularly without tiring. As an adaptation of a surface line to rapid transit, it may be said that in the operation of surface lines, considerable time can be saved by cutting out as many of the stops as possible by having each alternate car stop, rather than at every street intersection, at each alternate street crossing, thereby saving part of the time required to come to a full stop at about 50 per cent. of the crossings. This would cause no undue inconvenience to regular riders, as the cars could be designated in some way. The question has often been asked, "How large should a city really be before rapid transit is required?" To this question no definite answer can be given. It is no doubt

not so much a question of distance as of time that determines whether or not rapid transit facilities are necessary, and transit experts are generally agreed that when the population of a city approaches the half million mark, it is about time to look into the matter of rapid transit. Experience in American cities, however, demonstrates that the demand for transportation increases much more rapidly than the population. It is therefore well not to defer

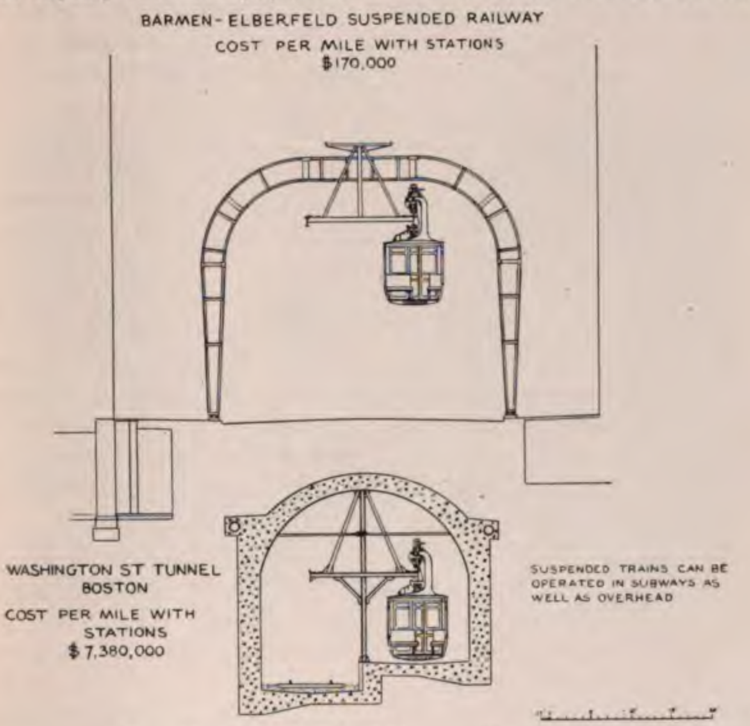

FIG. 12.—Barmen-Elberfeld suspended railway.

the making of a comprehensive scheme of transit but rather to consider it in connection with the general scheme of city development.

Subways are principally desirable because they furnish facilities for rapid transit without encroaching on or interfering with the street surface other than during construction, and because after construction they do not affect abutting property values unfavorably, nor do they interfere with the light and air as do other types

of structures, when placed on relatively narrow streets; but they are undesirable because of the bad hygienic conditions usually present and the undue financial burden they usually saddle on the community. Subways can be made to pay, if at all, only where there is congestion of population. Single family houses are not conducive to the payment of dividends on the financial investment required for subways.

Fares are invariably higher in the United States than in Europe but the haul is relatively longer. As the cost of passenger transportation is generally dependent on the density of traffic and the length of haul, transportation companies should cultivate the short haul business. This would indicate that considerable care should be exercised in locating the stations and that they should be placed reasonably close together and at all important points.

In planning subways or other high speed transportation facilities, the utmost consideration should be given to the routes to be followed, and there is little doubt in the mind of the writer that they should follow the established lines of travel rather than new lines, with a view to relieving congestion on the old lines which is seldom accomplished in this way. Correct City Planning requires that the future needs of the city be considered as well as the present, and therefore, where additional facilities are planned for relieving congestion or for the distribution of passengers, based on a knowledge of the present tendencies or the present direction of flow of the traffic, we should be extremely cautious to discover, if possible, whether it is likely that these tendencies are fixed, and be reasonably sure that there is no likelihood that in the near future there may not arise certain conditions to alter or change the direction of flow, and the advisability of projecting new lines into districts which give evidence of being future centers of industry, etc., or in which it is desirable to create such centers of business, manufacture, or residence, should not be overlooked.

The question of whether it is advisable to build the Subway roof close to the street surface in order that the distance to the station platform should be a minimum, even when this requires the entire rebuilding, or at least the readjustment, of all of the underground structures, such as sewers, water and gas pipes, electric ducts and pneumatic tubes, etc., or whether it is advisable to go below these structures at a cost due to the increase in the quantity of excavation, in excess of the cost of the shallow subway, but considerably

less by the amount of money required to make the changes in the underground structures, is important. At least one instance is brought to the mind of the writer of where a deep subway, even if built by tunneling methods, might have been cheaper than the entire rebuilding of the accessory structures. That subways are best fitted for certain kind of service and under certain conditions goes without saying, but there is no evidence of their universal applicability. There are those who think that wherever increased transit facilities are required, there a subway should be built, and many persons nowadays seem to be "subway mad," and due

Fig. 13.—Suspended railway under construction in Berlin.

weight is not always given to the many disadvantages of subways. Subways wherein are operated surface cars, as in our own city, are especially undesirable from an economic point of view, as they provide the most expensive kind of structure for the least possible financial return. It goes without saying, that only multiple-unit trains should be operated in subways.

Due consideration should be given to the "suspended railway" in successful operation for upwards of fifteen years in Barmen and Elberfeld in Rhenish Prussia. This type of structure, and, in fact, any ordinary elevated railroad structure is available as a means of rapid transit long before a subway can be considered, due to the

smaller first cost. The suspended type of elevated railroad is vastly superior to the ordinary elevated railroad in that it does not obstruct light and air, produces little or no noise, and the possibility of derailment is quite remote. It is deficient, however, in that there is no possibility of through-routing cars in connection with any other line because of the special equipment required to operate it.

The so-called "trackless trolley" is in operation in several European cities, notably Berlin (where it is designated the trolley bus) and in this country principally in the rural sections, and has much to commend it. It consists essentially of electric cars operated on the road surface (not on rails) hence the name, trackless trolley. The cars have solid rubber tired wheels and are propelled by motors mounted on the car axles, as in the case of ordinary electric cars, and take their power through a trolley operating on an overhead wire, with current generated in a central station. It is readily seen that there is considerable flexibility in this system and the cars can readily move from side to side over the road to pass vehicles of any nature, and this system is particularly desirable where an ordinary electric road operating on rails costs in excess of the amount which is justified by the traffic.

The mortorbus has more flexibility than any other type of vehicle used in passenger transportation, in that it can operate on any road or street which is available, and can as readily operate in the midst of such a congestion of pedestrian, car, wagon, and motor traffic as would preclude the use of any other system of transportation. In London, it is said to have solved the transit problem, and it needs no elaboration from me to justify its use on residence streets, or, on such other streets where surface and elevated lines are undesirable, and it is particularly well fitted to carry certain classes of people who object to riding long distances underground. According to statistics furnished by the London County Council, 500,000,000 passengers were carried on the motor busses alone in the year 1913. To give an idea of what this means by way of comparison, in New York City, during the year ending June, 1914, 652,000,000 passengers were carried on the entire New York Subway and Elevated Railroad system, or, in other words, the London motor busses in the year 1913, carried nearly 5-6 the number of passengers carried on the entire rapid transit system in New York City.

Subways for the distribution of freight directly from the railroads to the industrial and commercial establishments have been built

in this country, in Chicago, and operated by private corporation, and in several other places, notably Buenos Aires. There is little doubt of the fact that passenger subways can be utilized for this purpose at certain hours of the night during the intervals between the passenger trains where these are operated on a night schedule only where the subways happen to be connected with the railroad terminals and with the commercial establishments as well. Otherwise, an entirely separate and distinct system of tunnels will be required to be constructed for this purpose, and there is no doubt that the congestion on the street surface will be relieved to just that extent as there are vehicles engaged in this particular work. Of course, there are establishments which can never be reached by any system of freight subways, because, just as in the matter of passenger subways, there must be sufficient traffic to justify the expenditure, and the charges for freight handling and delivery by subway must compare favorably with the cost of handling the same material on the street surface.

Water Supply

Purification—Distribution

Water, which has been called the life blood of the organism named the City, must be secured in good and sufficient measure, of unimpeachable quality, and be dealt without stint to all, "if, when and as wanted."

Water for domestic purposes should be cool, clear, soft, and free from all taste, smell, and color; it should be neither salt nor sweet, should not be too heavily charged with mineral matter, and, to be palatable, should have free air in solution, and, above all, should be free from disease producing bacteria.

Of the water which falls on the surface as rain, the quantity which penetrates the ground and which flows in the streams is usually taken to be about 50 per cent. of the total. In the eastern United States, measurements taken over a long series of years have amply demonstrated that 800,000 gallons per square mile of catchment area per twenty-four hours is available for water supply.

City water supplies are usually taken from rivers, lakes, springs, and wells, and, where unusually large quantities of water are required, artificial lakes are sometimes created in the mounains by constructing dams across the valleys, whereby the rainfall of the drainage basin is gathered and stored and thence conducted to the city by means of open canals or tunnels, depending on the distance,

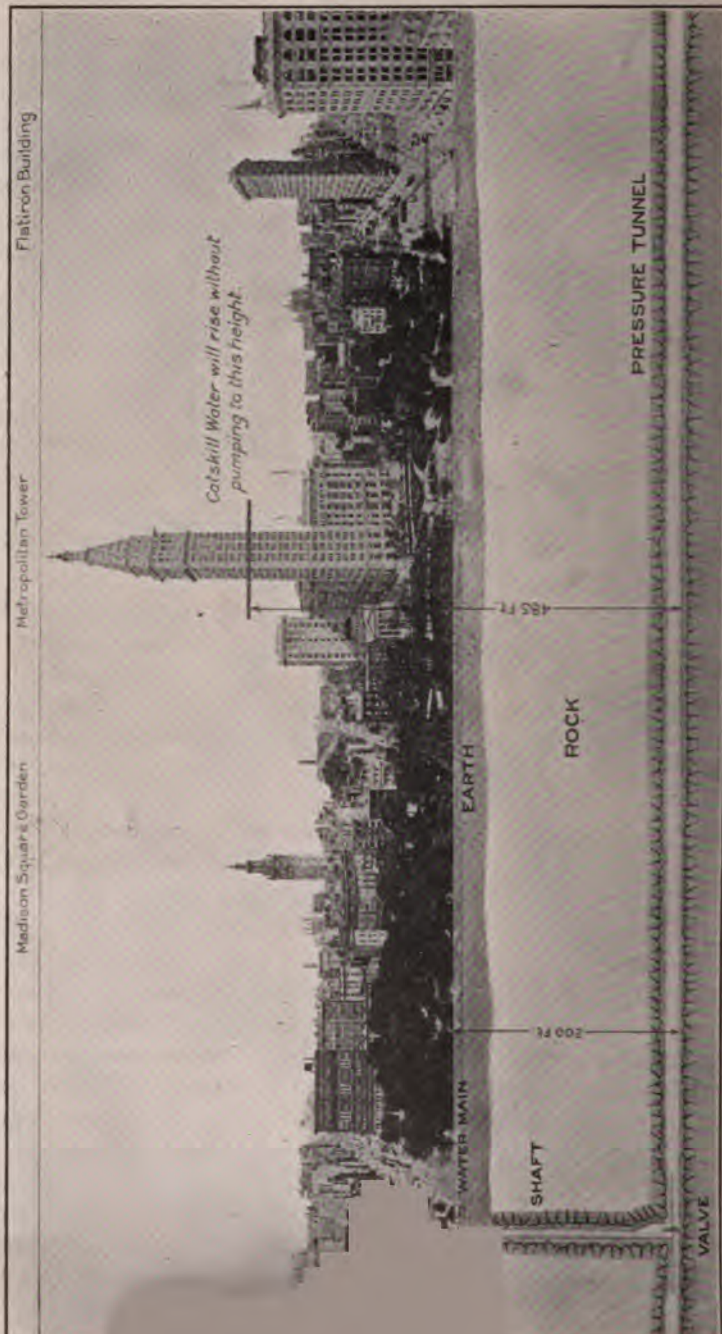

FIG. 14.—Catskill water supply, New York City, showing height to which water will rise by gravity.

the country to be traversed and the financial expenditure involved. River supplies, while generally furnishing water in quite large quantities, are subject to pollution, depending on the population inhabiting the water shed and to such casual or accidental pollution as may be occasioned by the discharge of sewage from vessels plying the waters.

Lake supplies are usually fundamentally of good quality, and where the drainage basin is only sparsely settled, generally furnish excellent supplies. The Great Lakes in this country are largely

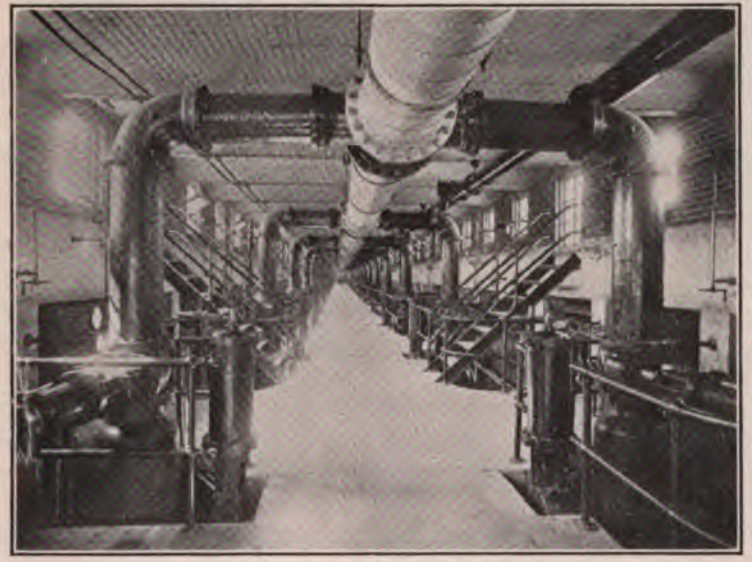

Fig. 15.—Torresdale, Rapid filter, operating floor.

used for water supply purposes, but these supplies are no longer considered safe without artificial purification, due to the contamination by shipping, and also to the density of population on their borders.

Supplies from springs, or ground water supplies, as they are generally designated, as compared with river supplies, invariably possess a lower summer temperature and a higher winter temperature. The ground water is merely the rain which has fallen on the surface which has percolated the soil to the water table whence it flows to some outlet, either ocean, lake, or some other water course.

While on the European Continent ground water forms the principal basis of many water supplies, cities in this country could not depend on these supplies to furnish the immense quantities of water required.

Deep or artesian supplies generally furnish water of a superior character, and while they are ample for the uses of small communities, cannot be looked upon as a source of supply for a community of such size as is usually designated a city. These waters are generally bright and sparkling, full of life, so to speak, and of unusual purity. If stored on the surface, the reservoirs should be covered to prevent the growth of plant life.

Artificial lakes or storage reservoirs are usually constructed, in order to conserve stream flow. Holding back or ponding the floodwaters allows of a more equable and uniform discharge of the waters over a much longer period. In designing such storage basins, consideration is usually given to the conditions that may exist, of having to furnish a supply over a long period of drought.

The quantity of water required for all purposes may vary in this country from 60 gallons per capita in a small town to 150 gallons per capita in a large city, and all above the latter figure is waste, pure and simple, only part of which can be saved by metering. The latter figure is more than twice as large as is the quantity used in any of the large European cities.

When the tap is opened and the water flows freely from it, usually no thought is given to the energy displayed by those whose foresight and skill made this possible.

In the city of Maharek and in the city of Manahmeh, the capital town of the Bahrein or Aval Islands in the Persian Gulf, there is no drinking water available, that of the gulf being salt, and therefore unfit for use. The islands themselves are low, flat, sandy stretches, raised only slightly above the sea level, in the region known to be the hottest on the face of the earth. Water for drinking and culinary purposes is obtained from springs said to have been discovered by pearl divers, located a mile or so from the shore, which bubble up through the sands in the bottom of the harbor and is procured by divers who go down to the bottom and place goat skin sacks over the gushing springs before they have a chance to mingle their waters with the brine of the gulf.

To the city of ancient Rome water was conducted through nine aqueducts of an aggregate length of 346 miles, built prior to the

beginning of the Christian Era, some of which are still in service, and the city of ancient Jerusalem was supplied with water through a tunnel about one-third of a mile in length, conducting the water from the Virgin's Pool in the Kedron Valley to the Pool of Siloam.

In England, many cities derive their water supplies from lakes situated at considerable distances from the cities themselves, the city of Liverpool having built an aqueduct seventy-seven miles in length to Vyrnwy in Wales to secure a suitable supply; and the city of Manchester has constructed an aqueduct ninety-six miles in length to Lake Thirlmere in Wales for a similar purpose.

The city of New York is now building an aqueduct one hundred and twenty miles in length from an artificial lake constructed in the Catskill Mountains for an additional supply.

The city of Philadelphia takes its water supply within the city limits from the rivers Delaware and Schuylkill, approximately 75 per cent. being taken from the former and 25 per cent. from the latter.

Many methods of purifying drinking water are known and some of them have been practiced for centuries. The Chinese used a piece of alum on the end of a stick for the purpose of clarifying water many centuries before the beginning of the present era. There is no doubt that in this process a partial purification of the water is effected, as the alum, on disintegrating, throws down a flocculent precipitate, which entangles and carries down with it many of the bacteria and other organisms present in the water, but this could not have been known to the ancients, as the very existence of these minute organisms was not known or even suspected until centuries after.

Different conceptions have at various times been held as to just what constitutes potable water. It is well known that the conceptions of the ancients could not have more than been based on those qualities that are directly discernible by the senses of sight, smell, taste, etc. This was succeeded in the long years that followed during which the Science of Chemisry was born by conceptions based solely on the chemical constituents of the water. Subsequently, during the years in which the chemistry of water was being developed, various standards came into being, based principally on the oxygen content of the water, followed by the period of the development of Sanitary Science which resulted in what is known as the sanitary analysis which is in use in our day. In the

sanitary analysis is indicated, among other things, the chlorine content of the water, which, when it exists in quantity in excess of that known to be normal in pure waters of the locality is taken to indicate sewage pollution. The analysis also indicates the quantity of organic matter present, in the water, in the various stages. It is a matter of fact that in the development of Sanitary Science various elements affecting the potability of a water supply not previously known have come to light. It is said that water otherwise potable, from a purely chemical standpoint, but infected by the addition of pure cultures of the cholera bacillus, was pronounced perfectly pure and fit to drink by the greatest chemist of his day, the Baron Lebig. The development of the science of Bacteriology has opened up a much wider field and through it the nature of a water supply is at once made much more accessible than at any time prior to its discovery. Biological studies of water supplies have also indicated organisms among the cryptogamic plants many times larger than the bacteria, as the algae, for instance, which are now known to affect the taste and smell of water which could in no other way be accounted for. It is therefore, seen that in order to pass judgment on the potability of a water supply, the chemical and biological characteristics of the water have to be determined and studied. With the various conceptions of purity, as applied to water, held at different times, were developed different methods of purification, and systems too numerous to mention have been used and many are now consigned to oblivion, because of the fact of their shortcomings having become evident as scientific knowledge respecting the impurities of water developed. The filtration processes occupy the center of the field, for, whether they are considered as merely straining processes, or whether they are considered as partly mechanical and partly biologic processes, ever since water filters were constructed at London, England, some eighty-five years ago, which were the first of which we have record, and until the present day, these processes are represented in by far the major part of the municipal plants for purifying water.

The London filters were constructed solely as mechanical strainers for the removal of suspended matters. There is little doubt that these filters were of considerable benefit in a sanitary sense, even though it does not seem to have been officially recognized until after the cholera epidemic, which occurred in the year 1849, when filtration by mandate of Parliament was made compulsory for the

entire water supply of the metropolitan district of London. In the same way that the filtration of the water supply has eliminated 90 per cent. or more of the typhoid fever, wherever such processes have been installed, sanitarians have predicted, and wisely, too, that the general health of the community would be affected by eliminating a large percentage of the intestinal diseases, as well as other diseases not usually attributed to impure water. It was not, however, until after the cholera epidemic in Hamburg, Germany, in 1892, that it became universally recognized that raw or untreated river water was unfit for use for drinking purposes.

It will be recalled that the city of Altona, situated adjacent to Hamburg, was practically unaffected by the cholera, and that this latter city took its water supply from the Elbe, as did Hamburg, only that in the case of Altona, the intakes for the water supply were below the outfall sewers of the city of Hamburg, and, consequently, the degree of pollution of the water supply of the city of Altona was far greater than was that of the former city. In Altona, a sand filtration plant for the purification of the water supply had been installed prior to the epidemic, in the neighboring city, and was in use at the time in question. This lent a considerable stimulus to the scientists engaged in this line of work in this country and abroad, and resulted in the classic studies by the Massachusetts State Board of Health on the purification of water and sewage, in which intermittent filtration was first promulgated as opposed to continuous filtration in use in certain European cities.

Prior to this time, no water filter plant had ever been operated (excepting experimental filters) at a rate in excess of about two and a half to three million gallons to the acre of filter surface per twenty-four hours, but subsequent experiments easily demonstrated that when the turbidity of the water was not excessive, rates as high as six million gallons per acre of filter surface per twenty-four hours were thoroughly practicable with the filter working continuously, as did the original filters of London, and as is the case with all of the filter plants of the slow sand or English type, as they are usually designated, in contradistinction to the type next to be described, and known as the American system. Admitting the fact that certain waters were cleansed and purified by means of the slow sand filter, and rendered hygienically far better than they existed in the natural state, and that, bacteriologically, they were more than 99 per cent. pure, it early became apparent that when the turbidity

of the water was caused by very finely divided clay particles, in some instances said to be smaller than the bacteria themselves, and, particularly, when the turbidity was high, the slow sand process was not at all efficient, and was very costly to construct and to maintain, as immense areas of filters had to be provided to allow an adequate number to be in service while the others were being cleaned. The mud, in many instances, entering the filters to a considerable depth, is only removable by the costly process of washing the sand beds. It was finally determined that waters containing from thirty to fifty parts per million of turbidity could not be efficiently and uninterruptedly filtered by this process, because with a removal of 90 per cent. there still remained five parts per million in the effluent in the latter case, which is about sufficient to be noticeable in an ordinary tumbler or drinking glass, and, in addition, it has been noted in many instances that these waters often deteriorate bacterially. The color possessed by many waters is not affected by slow sand filtration at all.

In the rapid or American process of filtration, the water is first treated chemically to cause a precipitation of the turbidity particles. This also acts as a bleach on the water and removes whatever color may be present, whether natural, as vegetal stain of bog waters, or color which results from pollution. The water is then passed rapidly (at the rate of about 125,000,000 gallons per acre of sand surface per 24 hours) or from twenty to forty times the usual rate of the English filter through the sand bed and thence to a reservoir to be delivered into the distribution. This type of filter is generally so equipped as to be mechanically washed at the expenditure of a small percentage of the water filtered, by a reversal of the current. It is found that this process is fully as efficient, bacteriologically, as is the English, or slow filter, is far more efficient for removing turbidity, is washed mechanically at far less expense, is more dependable when properly operated, costs considerably less for installation, and the operating cost, when considered together with the interest on the investment in land and plant, and with the sinking fund charges, is not only not in excess of that of the slow sand process, but rather considerably cheaper. As to the efficiency of this process, it may be said that everything of which the slow sand process is capable the rapid filter is also capable, but the reverse is not true. This process is generally taken to be far more efficient than the slow sand process today, and is fast supplanting it. Muni-

cipal plants of this type have been proposed for the cities of New York, Baltimore, Cleveland, etc., and several large plants are now under construction. It is curious to note that this type of filter was in use in this country before the continuous filter of the English type, but the use of chemicals, principally sulfate of alumina, was considered injurious to the human system, and this interfered with the natural growth of this system for many years, until it was again taken up on account of its economy of construction and its superiority of turbidity removal.

In the light of years of experience, this fear has now disappeared, and as the writer predicted in a paper read before this Club in June of 1912, prior to the time that the above mentioned plants were projected, the rapid or American filter will doubtless be the water filter of the future, and the slow sand, or English sand filter, is a thing of the past, so far as large municipal installations are concerned.

If I may be allowed to quote myself:

"The writer is convinced that the future water filtration process will partake of the nature of the mechanical filter, etc. The process will doubtless be preceded by sedimentation, precipitation with aluminum sulfate, and also sterilization with the ultra violet rays. The last process is still untried on the large scale. Most probably, hypochlorites will be used. This method has recently come into vogue and is very effective and economical and marks a considerable advance as well as a distinct era in the art of water purification." Nothing that has happened since the date of writing the foregoing paragraph would require a revision of its language when considered in its broadest sense. Sterilization with the ultra violet rays has never been applied on a large scale and it is questionable whether it ever will be a substitute for mechanical filtration.

As an adjunct to filtration but not as a substitute, the application of hypochlorite of lime or bleaching powder is valuable because of its selective qualities in destroying the intestinal and pathogenic bacteria. Liquid chlorine, which is obtainable commercially today, when applied to the effluent of a mechanical filter, is considerably easier of application than formerly, when it was applied as chloride of lime, etc., and is no doubt more effective as well. Plain sedimentation is a valuable process in water purification, where the water is of such a quality that all that is necessary is to clarify it

and where the particles in the water are of such a size and of such a nature as will readily subside in 24 hours. This seems to be the economical limit of sedimentation, for where it is found that the particles will not subside in that time it has been discovered that quite a long time will be required to effect the necessary clarification if it can be at all accomplished, and, in the latter case, the subsiding basins become quite large and necessarily costly. Owing to the fact that even where water is found reasonably pure and uncontaminated in nature, the chances of accidental pollution are so great as to demand some system of purification for what are generally called virgin waters, and the system most generally applicable and dependable is rapid filtration. The distribution of water from its source to the various users in a community is a problem of vast importance, as may be inferred from the fact that upwards of 75 per cent. of the cost of a water works system in a modern city is invested in the distributing pipes in the city streets. Distribution from the source to the users is generally effected in one of several ways. Water is either pumped through the distribution system or goes through the distribution system by gravity from a storage reservoir to which it has previously been pumped, which is preferable. Where the water is brought from a distance, aqueducts or deep tunnels or open canals are constructed, usually delivering the water to reservoirs located within the city, from which point the distribution proper starts. The entire subject is one which readily lends itself to a proper study of the economics of the various types of structure and certain other considerations such as the effect of earthquakes, of an invading army, etc. If aeration is required, it is usual to employ open channels for some part of the distance at least, in connection with fountains, cascades, etc., but examination of the water before and after going over the Falls of Niagara does not show any marked changes in the ammonia content of the water nor in the oxygen consumed, which is a measure of the organic impurities in the water; in other words, the water is not purified to any appreciable extent by such a process, but it is doubtless more palatable. In the distribution in city streets, cast iron pipes are usually employed. This material is practically indestructible, unless attacked electrolytically, which by proper care in laying can be prevented, and, in any event, can easily be remedied when discovered. Cast iron pipes first used in this country were made in England, but the "Made in America" kind today are used

throughout the whole world. The pipes are cast vertically so as to insure uniformity of thickness, which the old English pipes did not possess, and they are usually cast in 12 ft. lengths, which is somewhat longer than they originally were. It has been suggested in several instances that two separate and disinct distribution systems be provided, one for filtered water and the other for unfiltered, merely as a matter of economy, but this has not been done in this country, to my knowledge. Separate systems of pipes for fire purposes are not unusual in large cities at present, through which the water is pumped at high pressure, thus doing away with the cumbersome and otherwise uneconomical steam fire engine, and insuring a supply of water in great quantity and at such pressure as to be effective.

Cast iron pipes 60 inches in diameter are in successful use as pumping mains, and no pipe in the system should be less than six inches in diameter. Wrought iron and steel pipes are also used in distribution systems, but are not to be recommended, as they deteriorate far more rapidly in the ground than does cast iron pipe. Of the two, wrought iron is preferable, but its cost generally renders its use prohibitive. Deep tunnels in city streets where the streets are already occupied by other structures are sometimes used, and are generally more economical than an entire rearrangement of all of the other structures. These tunnels are connected to shafts at the street intersections, which shafts have connections with the distributing pipes from which the house services are taken. Where a number of large pipes side by side would be required for a given supply, a deep tunnel can often be constructed at less cost. The pipes should be cross connected at every street intersection and be amply provided with valves. Fire hydrants should be placed at sufficiently close intervals that the run of hose used in connection with any of them should not be excessive, and this is in itself a study of tremendous import when we consider the saving on insurance which is effected by ample fire protection, and it is a simple matter of mathematics to determine when a separate supply for this purpose becomes economical.

Sewerage, Sewage Purification and Sewage Disposal

Sewage is correctly defined as liquid household wastes, liquid manufacturing wastes, at all times nothing more nor less than dirty water, and in American cities seldom containing more than one or two parts of solid matter per thousand parts crude sewage.

Sewers and drains are provided for the purpose of gathering and removing the liquid waste from our midst, either in connection with the surface water, or separately, or, as it is commonly stated, cities are sewered on either the combined or separate systems. It cannot be stated in general terms as applicable to all cases that either of these systems is better than the other, but the proper system to use is dependent, more than on any other single thing, on the final disposition of the sewage. Where the sewage requires to be treated before it is discharged into a water course used for drinking

Fig. 16.—Emscher Tanks at Essen Nord.

purposes, it is obviously necessary to exclude from the sewers all rain water, excepting only that which falls on the street surface during the first few minutes of a storm which may approximate the household wastes in chemical and biological composition; because the more dilute the sewage, the more difficult to treat, and because the disposal works should for economic reasons be kept as small as possible. Where the sewage is discharged into a large stream or river, the combined system may be used to advantage, and a combination of both systems is often used in many places. The quantity to be provided for in the conduits differs in different localities with the water supply, which is generally accepted as a

measure of the quantity of sewage to be disposed of, and also with the rainfall, practically all of which flows from the street and roof surfaces after they have become saturated, so to speak, that is, after it has rained for some time. Where the separate system is used, the rain water leaders from the roofs are sometimes connected with the sewers to provide for occasional flushing, but more generally these sewers are provided with flush tanks connected with the city water supply for periodic flushing. Occasionally, the overflow

FIG. 17.—Pennypack Sprinkling Filter.

from the storm water conduit is connected with the sewage conduit to provide for the same purpose. In the combined system where the size of the sewers becomes at times considerable, occasional storm water overflows are provided to adjacent streams or water courses at such elevation above the invert of the sewer as to insure a sufficient and proper dilution of the sewage. Sewage interceptors are often built, paralleling water courses, and to these all connections are made, thus insuring against stream contamination.

Ventilation of sewers of either system is today accomplished by providing perforated covers on the manholes at the street surface, while formerly elaborate arrangements, such as stacks or

fans, were used to accomplish this purpose. Former theories of sewer ventilation were based on a misconception of the composition of sewer air. It has been determined that the bacteria in sewer air are derived from and related to those of the fresh air and not to those of the sewage, and there is no evidence that sewage is capable of directly giving up its organisms to the air. With reference to the quantity to be provided for in determining the size of the conduits, this is readily accomplished in the case of the sewage conduit of the separate system by making it of such a size as to provide for a flow at the rate of, say, two-thirds of the water supply during ten hours, which corresponds with the use of the water in American cities, at a velocity of about two and one half feet per second, which will prevent a deposition of the solids. To determine the quantity to be provided for in sewers of the combined system is rather more complex, as it requires that the rainstorms to which the locality is subject be observed for a long period, and that rate selected which seems to occur not infrequently, and this is to be taken sufficiently high, as it is the fairly large rainstorms which extend over a considerable length of time which are to be considered, rather than the unusual or infrequent and excessively high rates which endure for only a few minutes at a time. Rates of rainfall of from two to three inches per hour are usually used in computing the runoff from the drainage areas in American cities. Numerous formulas have been devised, some of which have a mathematical basis, for computing runoff from drainage areas, but many of these formulas contain factors derived from experiment, and hence cannot be considered of general applicability. The so-called rational method for computing runoff is in use today and is considered best practice. There is no necessity for any provision for sewage flow in sewers of the combined system, as the quantity of sewage to be provided for is usually less than three per cent. of the storm flow. Sewage conduits should be built so as to insure the sewage being kept in motion from the time it leaves the house until it reaches the outfall, which can be readily accomplished by giving the sewers a proper size, shape, alignment, and grade.

Sewage disposal is an art of rather ancient origin, but it is a fact that the necessity for sewage disposal works was not recognized until long after the necessity arose. Unlike other engineering works, the construction of water supply works, roads, bridges, etc., these have to precede or go hand in hand with the progress of a communi-

ty. Usually, however, the construction of a sewage disposal system is one of the last permanent improvements of a municipality. The problem of the disposal of sewage probably dates from the time when civilized man first began to live in communities, but, while the same ends were met then as now, it is not to be believed that the object in view was the same. The desire to rid themselves of effete matters was one which probably appealed to their senses rather than to any knowledge that they may have possessed of the harmful effect of living in close contact with organic matter in a state of decomposition. Long years of suffering and pain, in spite of the fact that many of the first principles of sanitation were understood at this time, were necessary to demonstrate to the world the real necessity of efficient means of sewage disposal. It was not until the immortal Pasteur propounded the theory of the decomposition of organic matter that the object of the disposal of sewage was presented clearly and unmistakably and made comprehensible to all.

The oxidation of organic matter or its complete transformation from an organic and unstable compound to a mineral form is effected by chemical means aided by bacterial action. The problem of sewage disposal is now and has been for years in a transitional stage, and because of this there are at least five distinct processes of sewage disposal practiced today, of the countless ones which have been devised. 1. Disposal by Dilution, so called, which consists of emptying the crude sewage or in connection with storm water into a stream of flowing water many times the sewage flow. 2. Irrigation Processes. 3. The Settling or Sedimentation, and also the Chemical Precipitation Processes, in which the sludge is precipitated by gravity or with some precipitant, and the liquid disposed of in the usual way. 4. The Bacterial Processes, in which the sludge is liquefied to some extent, and the liquid rendered more or less sterile, and 5th, the Disinfecting Processes. The latter processes, as well as the settling processes, are often used as adjuncts to the Bacterial Processes, rather than as distinct and separate processes in themselves, although it is altogether likely that the sterilization processes have sufficient merit to allow of their use as a distinct process where, for economic reasons, the more elaborate and costly processes cannot be applied, as are also various devices for screening the sewage prior to its purification by any process. These processes are described so well in the standard literature on

this subject that only a general description of the more important will be given. Of the first process, disposal by dilution, so called, it may be said that when a large body of rapidly flowing water, as a tidal estuary, is at hand, it is quite an efficient, as well as the most economical system, that can be devised. Serious complications may arise, however, if this same stream should be utilized for water supply below the outfall sewers. The question which would naturally arise is whether the sewage should be carried below the water intakes or whether it should be discharged into the water course without purification within the confines of the community in which it is produced, in which case the community below would be compelled to purify their water supply.

As a general proposition, the latter would be more economical for several reasons, but particularly because it would not be policy, nor would it be safe, to take it for granted that any system of sewage disposal was capable of rendering sewage fit to drink, even if it has been done in laboratory experiments.

There is no question but that the time is coming when crude sewage will not be allowed to be discharged into any inland stream, however large, without first subjecting it to some method of purification.

The application of sewage to the land for purposes of irrigation is dependent for its success on several factors, probably the most important of which is the nature of the soil, and when this is properly constituted it is quite an efficient method of disposal.

The cereals and fodder plants, on account of their greater absorption of moisture, can be grown, it seems, to the best advantage on a sewage irrigated field, and it has been frequently demonstrated that a place may be irrigated with sewage and cause no offense either to the health or the aesthetic sense of a community, with the possibility of earning for itself sufficient to pay running expenses. It is doubtful if sewage can be irrigated for profit.

The chemical precipitation processes which were largely the vogue in England for years, but which are being superseded, are deficient, in that the most that they can possibly accomplish is the clarification with some slight purification of the sewage. Milk of Lime, Perchloride of Iron, and Sulfate of Alumina are the usual precipitants employed. The principal objection to this process is that it does not reduce the sludge and that this still remains to be disposed of. The liquid matter is discharged into a stream or

water course, as is the case in the first instance. The sludge is generally dried and pressed and used for manural purposes, for which it has some slight value.

Among the bacterial processes, Intermittent Filtration as in the case of water is a biochemical-mechanical process and possesses great merit, but owing to the fact that the rate of application to the filters: viz., 50,000 to 150,000 gallons per acre daily, is rather small, the process becomes costly of installation and operation, particularly where natural sandy soils are not available, and where artificial filter beds would have to be built. It may be said that no large city could afford to provide and support a plant of this type, even though the process produces nonputrescible effluents and is remarkably efficient when judged by the usual standards.

What is recognized as the leading type of biological-mechanical filter today is really not a filter at all in the usual acceptance of the word. It is known as the percolating or trickling filter, in which the filtering material, so called, is coarse stone or gravel, and the principle employed is that of causing the sewage to move over the surface of the medium in thin films without filling the interstices in the material, in order to maintain the aerobic conditions necessary for the successful operation of the micro-organisms. With coarse material, however, the uniform distribution on the filter surface becomes quite difficult, and it is therefore necessary to resort to mechanical spraying of the sewage on the surface, which is generally accomplished by means of revolving sprinklers or fixed nozzles, of which there are many types. The effluent from this type of filter is generally very stable, i. e., nonputrescible. The rate of application of the sewage to the beds is usually at from 1.5 to 2 million gallons per acre per day, or say from 10 to 20 times the usual rate of application to Intermittent Filters. The type of filter is therefore seen to be much more economical to construct, owing to the considerably smaller filter area and consequently smaller land area required, as compared with a filter plant of the former type, as well as the fact that much simpler and cheaper methods of construction are available for this type of installation.

Settling tanks of various designs have been in use on the Continent of Europe for many years, but the one which bids fair to outstrip the others, both for clarification of the sewage and for the digestion of the sludge as well, is known as the Imhoff or Emscher Tank, respectively after the inventor and the name of the district

in Germany in which it was first used. The Imhoff tank differs from all other sedimentation tanks in that it is so constructed that the settled sewage and the sludge are separated from one another and the sewage passes off in a fresh state. The gases which are not offensive as they are in other types of settling tanks cannot escape through the entering sewage. The sludge produced is of a peaty nature, and can be used for filling in low lands, is practically free from all odors—so much so that plants of this type have been built quite close to habitations without causing offense.

The value of this process as a preliminary one is thus seen to be of tremendous value in sewage purification. The sewage, after being treated in the Imhoff tanks, is at present usually applied to the percolating filters, and when this latter process is followed by an application of the sterilizing process of the type mentioned under the topic, "Water Purification," the effluent becomes an almost sterile, and consequently a stable, one, and its ultimate discharge in a flowing stream is not likely to cause offense. This is no doubt the nearest to a perfect system (i. e., the combination, Imhoff Tank, percolating filters, liquid chlorine treatment) of sewage disposal of which we have knowledge. In this connection, however, it should be borne in mind that the treatment of sewage should not be made so complete that the sanitary benefit derived therefrom is incommensurate with the cost involved. This same point is made in the writer's paper previously quoted as regards the purification of drinking water, and, as a very keen observer and one of the best authorities on this subject puts it, "there is a great need of a keen sense of proper proportion in solving these and other sanitary questions."

Housing—Sanitation

As was said at the outset, the subject of this paper is such an extensive one that it would next to impossible to give more than a passing reference to many of the topics which may rightfully be considered as elements in the makeup of the modern city. In the mad rush to obtain the greatest measure of return from property held by private individuals and others, the physical well-being of the community is often lost sight of.

The housing problem is largely the result of high land values which create and foster congestion, and of the lack of transit facilities. It rightfully considers in its very broadest sense the environ-

ment of the dwelling house no less than the character of the dwellings themselves and the many and varied uses to which they are put. The connection between real estate values and the housing problem and the effect of proper housing on fire prevention and protection, as well as problems of municipal taxation and recreation, etc., should all receive and are deserving of serious consideration. These and many others, in their several aspects, moral, legal, and physical, which each bears to the other and to the whole problem present a subject worthy of the best thought of the community.

Fig. 18.—The Pantheon. Rue Soufflot. A fine type of dignified vistual street, leading to a world-famed building; note uniformity of building, evenness of sky line and perfect balance of entire composition.

The promiscuous piling of houses one on the other, so to speak, fronting on alleys or lanes or narrow streets, and the construction of tenements without adequate yard space, contrary to all ideas of decency and common sense and in defiance of every precept of sanitary science, rendering impossible the proper distribution of light and air, is responsible for much of the misery that is so graphically depicted in Riis's "How the Other Half Lives," that little that is new even fifteen years after the publication of that book remains to be said.

The width of the street and the distance between the houses, and the proper amount of yard space can readily be made matters of statute, as can also the kind and nature of street paving, with a view to minimizing the dust. No fixed rule can be laid down governing the amount of space that should be allotted to parks, playgrounds, squares, social centers, etc., but the necessities of each community will be amply satisfied when it is recognized that these facilities are required if the community is not alone to exist,

FIG. 19.—Boulevard Bois du Boulogne and Avenue de la Grande Armee. Some of the streets that Hausmann opened, radiating from the Arc du Triomphe.

but to prosper, and it can as readily be shown, if that be necessary, that it is a paying investment as well.

The vast advances in sanitary science which have been made since the discovery of the germ theory of disease should have prevented, in our modern cities at least, the occurrence of the old world conditions which give rise to a housing problem, but it is in defiance of and with utter disregard for this theory and all of the accumulated knowledge of mankind gathered on this subject during the last five thousand years that the residence sections of many of our modern cities have been built. The plague known as the "Black

Death" of the Middle Ages, which depopulated Europe, is generally ascribed to the ignorance and neglect of some of the fundamental principles of sanitation.

It may be said in the light of our present day knowledge that the scourge familiarly known as the "White Plague," for the spread of which bad housing is to the greatest extent responsible, can positively and undeniably be eradicated, and that twenty-five years of commercial prosperity and right living would forever banish it from our midst. With proper educational facilities, thus

FIG. 20.—Dusseldorf river front. Typical of continental cities situated on navigable streams; the water front is made attractive as well as useful and is invariably considered one of the city's very finest assets from the view-point of both business and beauty. (Note the low level for commerce and the high level for pleasure and promenade, as well as traffic).

insuring a decent respect for modern sanitary regulations, good housing (this includes good workshops and factories as well), correct living and working conditions, thus preventing overcrowding and too long hours of work, good water supply and ample sewerage, plenty of air and sunlight in abundance, with proper and sufficient food, and with no hereditary taint and consequently no predisposition to the disease, this dread disease could be forever wiped off the face of the earth. This, in my judgment, is the biggest dividend

that could be reasonably obtained or that can be expected to be paid as a return on the investment of good housing, with all that that implies. The experience of those who have made this a life study and who have had ample opportunity to observe it in all of its phases has demonstrated the absolute truth of this statement.

The protection against Asiatic Cholera by the filtration of drinking water at Altona in Germany was described under the topic of water purification, and the elimination, to a very large extent, of typhoid fever, as the result of an improved water supply, has

Fig. 21.—Essen. Types of streets and workmen's homes in the industrial community of Germany.

been amply demonstrated in our very midst. It is a well known fact that prior to the construction of the water filtration plant, typhoid fever epidemics were not of infrequent occurrence in this city. After the date of the commencement of operation of the several water purification plants, the normal typhoid (if it may be so designated) was reduced in each individual section of the city as it was supplied with filtered water, and subsequently, when the entire city was served, the reduction became very pronounced; and, while the decline has not been at all regular since the date when the first plant was put in operation, the typhoid in the city has been reduced from 634 cases, in the year 1903, per 100,000 population,

to 48.7 cases per 100,000 in the year 1914, as shown by the records of the Board of Health. When it is considered that typhoid fever is distinctly recognized as a water borne disease (although other sources of infection are also recognized, as, for instance, the common house fly, infected raw milk or raw shell fish, contaminated water-cress, etc.), this reduction seems all the more remarkable, because the disease from these latter sources is not affected and the reduction is therefore due entirely to the improved character of the water. The extermination of flies and mosquitoes has attracted considerable attention of late years. The discoveries made in Cuba, after occupation by the United States, by sanitarians and physicians in the Marine Service, substantiated a previously advanced theory that Yellow Fever was not a contagious or filth disease, but was transmitted by one human being to another by a particular species of mosquito. In the same service, after the United States took up the work of the construction of the Panama Canal, after considerable experimentation, it was discovered that Malaria was transmitted from one person to another by means of a mosquito of a different species from that producing Yellow Fever, and these two discoveries subsequently made possible, more than any other single thing, the Panama Canal. Had these two discoveries been made prior to the time that the French undertook the construction of the Canal, there is little doubt that they would have completed it.

The elimination of unnecessary noises and the prevention of the improper combustion of soft coal, commonly called the smoke nuisance, within the city limits, are both of them desiderata in the reckoning of the sanitary status of the city. The latter, where it occurs to any extent in addition to obscuring the beneficient light of the sun, is responsible for certain unsanitary conditions culminating in a disturbance of the pulmonary functions of the body, which should not be tolerated, as well as being responsible for certain mechanical interferences with plant life, which is recognized as an invaluable agent in regulating, to some extent, the temperature of our city streets.

Street and Roadway Paving

Some one has said that the character and condition of the roads was an index of the intelligence of the people in the respective communities in which the roads occur. This must evidently not be taken literally, because I am sure that it would not redound to the

credit of the American people as compared with some others. The first problem of road building is, of course, the securing of an economical location, but, as we are concerned in this paper with city streets alone, we have to follow the lines which, as has been pointed out earlier in the paper, are not necessarily fixed by economic considerations, and we are therefore more concerned with the roadway paving than with the location of the roads themselves. Generally speaking, the requirements of good pavements may be summed up as follows: They should be durable, noiseless, readily cleaned,

FIG. 22.—Bourneville, England. Compare these back yard gardens of an English industrial community, as well as those of a German industrial community, with the back yards of an American industrial community. (See Fig. 23)

must offer a good foothold for horses, have a small resistance to traffic, and should be readily repairable. Climatic conditions and the availability of certain materials will no doubt influence the choice of type, as will also the financial resources of the city. The purpose for which the roads or streets are to be used should influence us in determining the kind of paving and, while there are pavements which are good under all kinds of traffic, there certainly is one pavement above all others, although this may be largely a matter of judgment or, say, of opinion as to the best pavement for each in-

dividual case; and in determining the proper pavement to use in a given street the kind and amount of traffic should be the first consideration. Whether the street is a main thoroughfare, or whether it is merely a secondary street or a local street, should also enter largely into the choice, as should also the fact of whether the street is to be used as a business street or a residence street, or whether it is to be partly one and partly the other. On a business street, more noise can be tolerated than on a strictly residence

Fig. 23.—The back yards of an American industrial community.

street, although it should be minimized in all cases. Then again, in streets where heavy hauling has to be done, the fact as to the slipperiness, if I may be permitted to use the term, under all conditions, wet and dry, has to be seriously considered, and in every case the relative degree of cleanliness of the different pavements has to enter largely into the proper choice, with a view to eliminating those which are unsanitary or which are relatively difficult to keep clean. That pavement which offers the minimum resistance to vehicular travel is the one which will no doubt affect heavy hauling and therefore be given due consideration on streets adapted

to or set side for that purpose. Of course, in summarizing the various factors and comparing the one with the other, the durability, the first cost, and the cost of maintenance enter largely, and the relative ease with which a pavement can be repaired under traffic and the degree of perfection obtainable in making repairs to which a pavement lends itself, so to speak, are all determining factors in the ultimate choice of a street paving. This latter point, in the judgment of the writer, is the *bete noir* of the whole subject of street paving in American cities. The constant cutting of ditches through and the tearing up of the street paving for the purpose of placing certain subterranean structures and for making repairs and additions to those already in place is such a constant and ever-present practice in this country as to a most preclude, and is certainly a serious hindrance, to the keeping of the street in first class condition. And this brings us to a point, the construction of the so-called "Pipe Galleries" of some of the European and South American cities and of certain of the cities of this country as well, which has been attended with some degree of success. These structures, while supplying a long felt want in certain directions, are hopelessly without virtue in others. It may be said, in passing, that the Gas Companies are unalterably opposed, and rightfully, too, to placing their pumping or distribution mains in these structures wherein are also housed the high tension electric distribution cables. Municipally owned pipe galleries present the best solution today of the problem of ridding our city streets of the overhead wires which are such a constant menace and which disfigure the landscape to an incalculable extent, and it is believed that they can be operated for profit. The poorest paved streets in American cities are, no doubt, those in which street car tracks are located. Alongside of, and between the rails, the paving is generally not very satisfactory, nor is it usually up to the standard around the access manholes to the various underground structures, many of which are often present in our principal traffic streets.

Innumerable types of street or roadway pavement have been devised, but those in use today can be placed in one or other of the following classes:

Macadam pavements, consisting of several graded layers of broken or crushed stone with a top, dressing of screenings generally wetted in the process of rolling to assist in compacting and usually designated water bound.

Block pavements, consisting of rectangular blocks of (1) natural stone or (2) wood, treated or untreated, or of (3) manufactured material laid either on the earth subgrade or preferably on a concrete base.

Sheet Pavements (1) consisting of asphalt mastic or rock asphalt laid on a sub base of stone concrete with a binder course between the asphalt and the concrete foundation, consisting of small, graded, broken stone, mixed with an asphaltic cement. (2) Concrete

Fig. 24.—Illustrating the old monotonous 30-ft. street in Philadelphia, the great advance that has been made as shown by the street in the Girard Estate. (See Fig. 25.)

roadways in general. (3) Bituminous macadam wearing surface, placed on a previously laid macadam pavement or a stone concrete base.

Representative types of each class will be described.

The macadam pavement is now and has been for years a favorite pavement, and, all things considered, is probably the best and cheapest pavement that can be laid for accommodating ordinary or light traffic, unless the sheet concrete pavement, of which many

miles are today under construction in this country, should prove themselves superior by reason of the less cost of maintenance, which is not at all improbable. With the advent of the automobile and motor driven vehicles in general, it was demonstrated that the ordinary water bound macadam road was incapable of withstanding the tremendous wear, particularly when there is considerable traffic, and the so-called bituminous macadam wearing surface has been devised to supplement it or to take its place, which it does with eminent satisfaction at a reasonable cost.

Two methods of production of this type of pavement are in vogue, the penetration method and the mixing method. In the former, the stone road is built in the usual way and the bituminous material is spread on the surface and thoroughly rolled. A flush coat of the same material is then applied, and, after the application of the stone screenings, is rolled to form the final wearing surface. In the latter method, designated the mixing method, the various materials, the graded aggregate, the bituminous material, etc., are mixed by machine, thus insuring a more intimate mixture than it is possible to obtain by means of the penetration method. It is then placed as a wearing surface on a previously prepared macadam pavement or a concrete base, the latter being preferable. All things considered, there is little doubt that the mixing method is the more economical method of the two, although the first cost may be somewhat more than the other.

The cut granite or trap block pavement on a substantial concrete base is pre-eminently the pavement for heavy traffic. Where the blocks are well cut and properly laid, and where the joints are filled with gravel or stone screenings and with cement grout, the pavement presents a reasonably smooth surface. In many instances the joints are filled with gravel and grouted with hot pitch and sand mixture. This type of pavement is more durable, more easily and satisfactorily repaired than almost any other pavement, is not at all slippery, can be laid, and is satisfactory on any grade. It presents somewhat more resistance to traffic, it is probably slightly more difficult to keep clean and the noise of passing vehicles is somewhat more than on other pavements, as the wood block or asphalt, on which the sound is to some extent muffled. The cost of maintenance, however, is low, compared with some other types, but the first cost is quite high. The pavement will last an indefinite time.

The creosoted wood block pavement shares with the cut granite block pavement many of the qualities which are desirable in a street paving to accommodate the heaviest traffic, although some authorities assert that the durability of a wood block pavement is governed not so much by the weight of the traffic as by its density. The wood block pavement is more desirable in that it is more easily cleaned and because it presents less resistance to travel than does the granite block. The moving vehicles do not create as much noise as they do on a granite block pavement, but the pavement,

FIG. 25.—Street in South Philadelphia—Stephen Girard Estate Improvement

while not slippery in dry weather, is quite slippery in wet weather and it does not give sufficient foothold for horses where it is used on too steep a grade, while granite block paving, as has been pointed out, can be used on any grade. Wherever wood block pavement is used, there is always more or less trouble with expansion and contraction under changes in weather conditions. There may also be considerable bleeding or sweating which is quite objectionable. The pavement is durable and less dust producing and therefore more sanitary than, possibly, any other paving material and costs about the same as granite when laid on a similar foundation. Various kinds of wood have been used for this purpose, but the one

which seems to give the most satisfaction in this country is long leaf yellow pine. Wood block paving is not as readily repaired, nor is it possible to restore the paving in making repairs, equal to the original, as is the case with granite block. The life of creosoted wood block pavement is probably ten years. Kyanized blocks, wood block treated by the Chloride of Mercury process, Burnetized blocks, wood block treated by the Chloride of Zinc process, have been used to some extent, as have also untreated blocks, generally of hard wood, notably Jarrah wood, with more or less satisfaction.

Sheet Pavements

Under certain conditions, sheet asphalt possesses advantages over all other types, and for use in residential and light traffic streets it cannot be surpassed. This type is noiseless, is far more easily cleaned and costs considerably less than either granite or wood block paving. Owing to the fact that it is noiseless, it is probably more suitable for residence streets than any other type of paving, unless it be the so-called bituminous macadam. It can be laid absolutely true and with an even surface and presents a pleasing appearance, but it is extremely difficult to properly repair and therefore should not be used on any street which is at all likely to be torn up (if that can be foreseen) for any purpose whatever. It is not unusual to use gutters of vitrified block in connection with asphalt roadways, because of the injurious action of the water on the asphalt, particularly on flat grades.

The concrete roadway with a concrete wearing surface is probably the latest innovation in this line of work. Owing to its low tractive resistance, it is possible for a horse to draw a far heavier load with much less effort over a road of this type than over any other. The road is usually built with a low crown and can be made practically impervious to water. For motor driven vehicles, the road seems to be well adapted, and under certain conditions no doubt this type of road will compete with the macadam road for use in suburban sections and for country roads for which it seems to be particularly well adapted.

Merely as a tentative suggestion, the adaptability of the different types of roadway paving may be summarized as follows:

Heaviest Traffic—Business and Manufacturing districts, water front streets, etc.	Granite Block
Heavy Traffic—Business District	Creosoted Wood Block
Ordinary Traffic—Business and Residential Districts	Sheet Asphalt
Light Traffic—Residential and Suburban Districts Motor and Horse Travel	Bituminous Macadam

Miscellaneous

To attempt to define and to treat of all the subjects which may be said to be elements of the modern city is a rather forbidding task for the subject of a paper and I have therefore only attempted to describe the fundamentals, and if I have fairly well succeeded in doing this, I will consider that my efforts have not been in vain. It must be admitted that it is an utter impossibility to plan in advance the construction of any large city in all of its elements. It may be said right here that the principal attributes of a city planner are his foresight and his imagination, and a man who can not dream of the ideal and who is unacquainted with the requirements and desires and hopes of a community is unfit to enter upon such work. Of course, technical ability also is necessary, but this must always be subordinated to one's power of imagination and perception and the other attributes herein mentioned. Nor has a city ever been planned since the world began in the sense that Modern City planning contemplates. It is true, as was stated earlier in this paper, that the streets of several of the ancient cities, cities built hundreds of years before the Christian Era, were built in accordance with a pre-arranged plan, but this is as far as the ancients, and in fact many of the moderns, ever got. There are the garden cities and working men's colonies and also industrial cities in this country and in Europe, as Gary and Essen, which have been built around large industrial institutions and which have been thoroughly thought out in advance, at least in all of the principal elements, but by far all of the cities which we call modern have, as has been stated, been replanned and rebuilt, and in any dissertation on this subject, the science and art of replanning a city is what is meant, rather than planning *ab initio*. A properly replanned city should contain all of the elements required to correct the defective planning, whether intentional or otherwise, of the original city. The expression, "cities grow like other organisms," has been used advisedly in this paper, and the fact of the matter is that the modern city is rather a product of evolution than an entity that could possibly

have been foreordained. Streets have been widened, lengthened, and straightened. Building codes have been formulated, corrected, and improved. The single center square has given way to the chain of parks, squares, recreation centers, and playgrounds. The horse railway has been superseded by the cable road, the electric trolley road, and this in turn supplemented by the high speed lines, using in the regular order the elevated railroad and the subway, and so on for all of the other elements. The higher and more desirable has always been evolved from the lower and less desirable and less useful, and today from the less ornamental as well.

Something has been said of the rational of housing, but there has been nothing said of waterfront and harbor improvements, of bridges and their approaches (which should rightfully be treated in connection with roads), of building regulations, of waste disposal other than sewage, of electric current generation and distribution, belt line railroads, gas manufacture and distribution, street lighting, and the thousand and one other subjects, because time forbids, and also because they are not necessarily to be reckoned among the fundamental elements of which this paper is intended to treat.

Conclusion

A Plea for a Smaller City

Why cities vie with each other in matters of population or area with a view to securing the biggest is inconceivable. From certain points of view, the financial problem involved and certain sociological problems may be easier of accomplishment, but many of the topics alluded to in this paper only become problems of serious concern when the population becomes considerable and when the area of the city is increased unduly. For instance, in a city of, say, 200,000 inhabitants, there is not nor can there be a transit problem, as a place which is used as the habitat of a fifth of a million of persons is scarcely big enough to require rapid transit. With the increase in population beyond a certain limit, however, an increase in area is required, and as the population moves away from the old residence section to the suburbs, which is usual, some means of transit must be provided between the business section and the new residence section, and with each material addition to population and consequent increase in size the people move further away, eventually requiring that high speed lines be introduced. Nor are

the water and sewerage problems and the housing problem and the water purification and sewage disposal problems generally of serious concern until the municipality has attained a certain size, as all of these problems are more easily solved and all of these facilities more easily provided for a small community than for a correspondingly large one, and, in the case of large cities, additional problems come up from time to time which were not a part of the original scheme and which become extremely difficult to correlate with the whole. The dictum of the biologists can here be reasonably applied (as the City has been compared with the human organism) that an organism is not necessarily higher in the scale of being if it is simply larger or more complex. The former can exist under much more simple conditions and may therefore be compared in fitness with a more complex organism which requires more complex conditions under which to survive and thrive.

The small city with its simple problems can therefore well compare with the larger city in which every one of its physical problems is more involved and more complex.

PAPER NO. 1149

TRAINING THE ENGINEERING SALESMAN

BY R. L. GILLISPIE

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The early history of The Pennsylvania Steel Company is that of a company making rails and some finished steel in a period when steel was divided roughly into two grades—hard steel and soft steel, hard steel being any steel that would hold a temper, and soft steel being all other kinds. Rails were rails, and were inspected for surface defects only, and billets were "run of mill." The condition existed (which was not confined to our company) that Salesmen were usually commission agents, and it would frequently occur that if a buyer were shrewd enough to send his inquiry to two or three of the agents of the one steel company, he would get two or three prices on the same product from the different commission agents of the same company. With the development and refinement of the steel business, and the diversification of products, the necessity for doing away with such loose methods became more and more apparent, and most steel companies established sales offices of their own, doing away with costly commissions. In the case of our own Company, the type of salesman required seemed to be a man who had had some office experience, could write on the typewriter, keep some books, and had some facility for uttering glib phrases which he had picked out of the Company's catalogue. The sales department was looked on as a necessary evil, and as the final resting-place of men who had outgrown the position of clerk but yet were not competent to take an operating position in the mill. While some of these men succeeded, many failed, and it was realized that something better was required, and that some of these men, while perfectly competent to handle the ordinary routine work of a sales office, were not competent to handle big business, or to make proper representatives for the Company before higher railroad officials, who themselves were trained and competent men.

In the year 1900, therefore, The Pennsylvania Steel Company inaugurated a policy of taking men just graduated from college, putting them into their Works to obtain a practical knowledge of the steel business, and graduating them from the Works to take up the lowest position in one of their sales offices, with a view to seeing if these men, specially trained, would rise up through the various grades in the sales office, until after a period of years a sales organization of educated men, trained in the Company's own method of doing business, could be produced.

At the start it was felt that it would be desirable to take college men, not because the college man in himself is any more fit than many men without a college education, but because a man with a college degree offered a rough and ready selection which it was necessary to make at some point. In other words, it was assumed that a college man would have a certain requisite fundamental schooling which would enable him to read and study intelligently about his life's work.

Applications for the position of Sales Learner receive the personal attention of the General Manager of Sales and an interview with him is necessary before the man is employed. In this interview questions are asked which are designed to bring out not only the extent of the applicant's technical training but also such questions as reveal the caliber of the man—what branches of activity other than scholastic he was engaged in while in college, what business experience he has had if any, and how large a general knowledge he has of the subjects of the day. In short the policy of the Company is not to seek the specially trained chemist, mining engineer, or civil engineer. Some knowledge of all these subjects is of distinct advantage to the applicant. But it is considered more important for the purpose in hand to secure a man who is broadly educated, who possesses some social ease, meets people easily, has a good presence, and who can talk intelligently, if necessary, on subjects other than those closely allied with the details of the steel industry. To such a man the sales learners' course of instruction is designed to bring a general knowledge of the technical side of the manufacture and properties of steel.

Let me state again that the knowledge acquired is general. The course does not graduate a man capable of making a complete survey for a job of street railway special work. If it did, it would probably produce a better engineer but a poorer salesman and

the course is designed to teach men the fundamentals of the Selling problems he will meet in representing The Pennsylvania Steel Company. We do not think that the best of salesmen would make the best of engineers. Neither do we think the best of engineers would necessarily be the best of salesmen.

The sales department organization comprises forty to fifty men. Nine sales offices, each in charge of a District Sales Manager, are located in the several large cities of the country and each has two to five salesmen. There are also Sales Managers of three departments where the products are so special as to require the entire attention of one man. In charge of the Selling organization of the Company is the General Manager of Sales, located in Philadelphia.

The products which The Pennsylvania Steel Company now manufacture are very diversified. Starting with the crudest of all, Pig Iron, the Company also manufactures the so-called semi-finished grades of steel, billets, blooms, and slabs, and the finished Rolling Mill products, rails and rail fastenings, bars, and structural shapes. A large Steel Foundry and completely equipped Forge Department require the expenditure of much selling effort. Perhaps the most highly finished of all the products which are sold by the general salesman is that of the Frog and Switch Department, where all classes of Track material, switches, frogs, crossings, etc., for Steam and Electric railroad are fabricated. In addition the Bridge and Construction Department of The Pennsylvania Steel Company and the Marine Department of the Maryland Steel Company do a very large business, but the product of these two Departments is so highly specialized that their sale is largely handled by the respective department organizations.

The successful applicant for the position of Sales Learner is first sent to Steelton, Pa., where the main plant of The Pennsylvania Steel Company is located. While at the Works, he is considered as a member of the Operating force, reporting directly to the operating management and coming under the jurisdiction of the Vice-President's office. The purpose is to have the learner spend a certain amount of time in each of the sub-departments of the Company, and to this end a course of instruction is prepared which provides for the period to be spent in each mill. Usually it requires one year to eighteen months for the learner to complete his operating course. Nine or ten hours a day spent at the actual scene of operations permits a man to acquire a very respectable general knowledge of the details of the business in this time.

The Blast Furnace Department is the foundation of the steel industry, if we omit the actual mining of the ore, and so the learner is naturally sent to this Department to start his operating course. Two months are allotted for this work. There is but little actual manual labor that a green man can do in this period. We do not expect him to wheel coke or stone "buggies," pick out the tapping hole or run the stoves. But he is expected to familiarize himself with Blast Furnace practice. He should note the size and construction of the furnace, why it is called a Blast Furnace, and how it is controlled. He is expected to make a complete study of what goes into the furnace, where it goes in, and how it goes in. And the same with what comes out. So far as possible it is important that he learn the technical terms, often the non-scientific terms, employed by the furnace operators. Particularly, through association with the Superintendent, Assistant Superintendent, or Furnace foreman, the learner should have a clear conception of what is being made. He is encouraged to ask questions. For instance, if the furnace is burdened to make high silicon iron, the learner should watch the casts, get some idea as to the appearance of the fracture of this grade of iron, and check up his guess as to its silicon contents with reported laboratory analysis. He should also know for what purpose this grade of iron is intended so that, later on, he may associate his experience in the Blast Furnace Department with his experience in the Bessemer and Open Hearth Departments.

There are many grades of Pig Iron, some of which the learner will see being made and others which he will not see. It is expected that he will have interest enough in the general subject of Pig Iron, its grades, uses, and manufacture, to find out from other sources than actual observation what the various grades are.

After spending his allotted time at the Blast Furnaces, the man is assigned to the Chemical laboratory for one month. During this period he learns more about *what* is done than *how* it is done. We do not desire that the man be a trained chemist capable of making an analysis for combined and graphite carbon in iron—it is not necessary that he should be in order to sell Pig Iron; but it is expected that he learn that the standard analysis of Pig Iron calls for determination of silicon, sulphur, and phosphorus, and he should associate this fact with what he previously learned about the grades of iron. Similarly, he learns that the ladle analysis of the test piece from the Open Hearth requires determination of car-

bon, phosphorus, sulphur, and manganese and that to this list, the later check analysis adds nickel and chromium. In connection with this chemical analysis, the future salesman should know how drillings for such are made. Then, if at some time in his career it is necessary for him to investigate an alleged complaint, he will be competent to direct the proper sampling of the material shipped.

After getting this fundamental idea of the smelting of iron from ore and what this iron is composed of, the learner is assigned for a period of two months to the steel making plants proper, the Bessemer and Open Hearth departments. As arranged at Steelton, these two processes are carried on in the same large mill. Hence the man could not have a better opportunity to acquire a knowledge of the two radically different methods. He will soon learn why blowing cold air through molten iron instead of chilling it actually raises the temperature and the different means employed to produce the heat in the Open Hearth furnaces. At first about all he can do is observe the various operations. Later, after becoming somewhat familiar with the course of procedure, he can ask intelligent questions. Here again it is expected that a knowledge of the construction of the furnaces be gained. Very often a learner will find that one of them is being re-constructed and this allows him to get down underneath it and find out how the regenerating chambers are built, where they are located, and how they conserve the heat that would otherwise go up the stack. During his observation of the running of the mill, it should soon become apparent to the careful observer that there is a close inter-relation between the units with which he is already familiar. He will see how the iron that is received from the Blast furnaces is kept hot in the mixer, how dependent the Bessemer is upon the supply of hot iron, and how, in the duplex Open Hearth process, the Open Hearth furnaces depend upon the Bessemer. It is advisable that he return for a day to the Blast furnaces and trace a cast from there to the Bessemer and Open Hearth, following the heat of steel still further as it is poured into ingots. Later on he will see where the ingots go.

But perhaps more important than the knowledge of the operation of the mill which he gains is the knowledge of the various grades of steel. Bessemer steel is not marketed from Steelton as such, the Bessemer plant being, at present, an adjunct to the Open Hearth. But Open Hearth steel is made in all grades and for all purposes. A large part of the products of the Company is in the so-called semi-finished

form of billets. We make extra-dead soft steel, soft steel, medium steel, and high carbon steel with Manganese content as required. We also make Alloy steel, 3½% nickel, Mayari or 1½% nickel chrome steel, vanadium, chrome vanadium, and nickel chrome vanadium. Rail steel is made in thousands of tons. The learner in the Works has his golden opportunity to see all these different grades made. He will be informed what specifications are being worked to and his laboratory experience will tell him what such specifications mean. It should immediately occur to him to wonder why there are so many different grades, why there have to be so many, and it is there that he probably first learns the answer to some of the questions which will be asked him later when he is a thousand miles from the mill. It is necessary that he absorb information like a sponge and the greater his absorbing and retaining power the better it is for him and his employer. His ability along this line is tested, as I expect to bring out later.

After five months thus spent in learning how steel is made, the future salesman is given an opportunity to see what it is made into. He is sent to the Rail Mill first and is probably astonished at the apparent ease with which a 22-inch square ingot is rolled into four 33′ rails. But when his astonishment wears off as his experience grows, he discovers what care and watchfulness of all the steps in the process are necessary in order to produce the perfect product. He learns that the steel must be right in chemical analysis, and in physical structure. He gains some knowledge of the attention that must be given to insure proper heating of ingots and blooms and at the roll-crane itself he may see how the finished section is more nearly approximated, pass by pass, as the bloom is reduced to the rail. Of course, there are a vast number of details to be picked up, such as the various sections of rails, their weights and section numbers, and the significance of the branding marks. The learner also studies the drop testing and should spend every minute of time that he can with the rail inspector who tramps back and forth over the pile of rails searching for surface defects.

In addition to his observation at the Rail Mill, some time is spent at the reversing blooming mill and the Universal Slab mill, where a study is made of the sizes that the mills are prepared to roll and also of the semi-finished forms in which the special grades of steel that he saw being made in the Open Hearth are shipped. At this point in his course, he finds out what customers purchase such grades and he is then in position to get some idea of what they are used for.

From the foregoing, it will be seen that the sales learner's course is designed to give a man a knowledge of just as many practical details as he can grasp. I should be in danger of repeating were I to describe his assignments in the Forge Department, Steel Foundry, and Merchant Rolling Mill. In each of these, it is expected that he learn primarily what the department can make to the best advantage and all that he can of the actual making of it. In the Forge Department, he studies the capacity of the various presses and hammers, and learns something about heat-treating. In the Merchant Mill, what sizes of structural shapes and bars are rolled and what types of rail joints and track fastenings are manufactured. In the Steel Foundry, he is given a job as a molder's helper and learns in a way that he could not otherwise the care that it is necessary to exercise throughout all the steps in the making of a casting. A month's time is allotted to each of these Departments.

It was mentioned above that probably the most highly finished product which is sold by the ordinary salesman is that of the Frog and Switch Department. The business of this Department is one of vast detail. Its product is shipped to practically every state in the United States, and its capacity for certain kinds of track material is almost as great as that of its fifteen or twenty competitors combined. All classes of track work are fabricated for both Street Railways and Steam Railroads. Street Railway work consists of curves, crossings, frogs, switches, and involved layouts, made of standard Tee rail, high Tee rail, or girder rail, and in "bolted," "cast steel," "ironbound hard center," and "solid manganese" construction. It is well called "Special Work" for almost every job is unique. It requires a fair amount of a knowledge of surveying to lay out its curves, although all the problems that occur may be solved with plain trigonometry. Steam Railroad work is not as involved in this way but more so in another. In the present day of standardization, almost every railroad has its own standard design for track material. It would seem that there must be one best design of a device for all roads, the adoption of which would relieve the manufacturer of a large amount of trouble. But they differ—even to the kind of a cotter pin put through a frog bolt.

The Frog and Switch Department has seven or eight sub-departments of its own. A sales learner spends four to six months working in the shop at this point or that, taking notes, asking questions, scanning blue prints, and absorbing every last detail that he can.

He is equipped with complete catalogues of the standard products made and has ready access to the catalogues of competitors for purposes of comparison. If he cannot get his questions satisfactorily answered by the men in the shop, he is at perfect liberty to go to the Sales Manager of the department, Chief Engineer, or Superintendent himself. While assigned to the Frog and Switch Department the man is sent on the roads for a week with an experienced companion and given some idea of where the material goes that he has seen fabricated. The amount of information required to fill a Frog and Switch Department order is large—the learner is expected to find out what that necessary information is. As he goes through the Works, he usually finds that where all was confusion at first, order gradually evolves out of the chaos that existed in his mind and at the end of the period he thinks he is competent—until he finds himself a hundred miles away some day when a new detail will present itself to him.

One month of his apprenticeship is spent at the Bridge and Construction Department. In this time, the best that the learner can do is to get a very slight idea of different designs—cantilever, suspension, plate girder, box girder, Scherzer, etc. It is manifestly impossible for him to learn any of the details and, as stated above, the sales of the product of this Department are handled by the Department organization. The function of the Sales department is to represent the shop to the customer rather than to actually be an agent qualified to discuss details of manufacture.

Finishing this, the learner enters upon a very interesting portion of his course and takes up his assignment in the physical testing laboratory. While there he comes to know what physical specifications mean, how they differ for different materials, and how physical tests are made. All the previous knowledge which has been gained may be correlated while the learner is a member of the testing laboratory force and it is a most valuable part of his training. His work is supervised by the Engineer of Tests.

To finish his operating course, the sales learner has his last assignment in the General Order Department of the Company. During this period, he gains some idea of the necessity of taking particular care with clerical details of writing orders in order that no mistake may occur in the filling of them. He also learns how important it is for the distant sales office to supply the mill with sufficient information in the first instance to adequately fill an order.

In addition to his assignments to the various departments of the Works, as outlined above, the sales learner is required to do considerable collateral reading. In this way he acquires a knowledge of the theoretical side of the metallurgy of iron and steel and should so arrange his readings that he will be studying from books the subjects with which he is associated during his working hours. He has access to the library of technical books which are filed in the office of the Vice-President. Recommendations are made to him as to what books are best suited to his purpose.

Each month while the man is in the Works he is required to make a complete report on what he has learned. A copy of this report goes to the General Manager of Sales and is carefully read and and criticised. In fact, cases are not uncommon where the sales learner's report has been brought to the direct attention of the President of the Company in Philadelphia, and in one case, at least, where the report was exceptionally praiseworthy, was mentioned to the Board of Directors at a regular meeting. These reports serve a two-fold purpose. Not only do they give those in authority an opportunity to gauge the work the man is capable of doing, but the mere writing of them fixes in his mind the things he has learned.

It is apparent that the learner has an excellent opportunity to gain a knowledge of the technical side of the industry. But the salesman must also know the terms and methods used in ordinary business transactions. He cannot become familiar with this side of his future work while in the mill and to the end that it may not pass unnoticed there is a list of some hundred and fifty questions with which he is furnished and to which he must learn the answers. These questions are subdivided under various subjects such as "abbreviations of business terms," "Freight matters," "Financial terms," "Financial organization of corporations," "Organization of The Penna. Steel Company," etc. They are not technical questions in the main, but have to do entirely with matters that are current in any business transaction, regardless of its nature. They are an important part of the learner's education, for during the time that this learner's course has been in existence we have found that the ignorance of the ordinary college graduate, in respect to general business knowledge, is very great. After a man finished his course and is assigned to a sales office, he is still very green. Frequently we have found a man did not know the meaning of "f. o. b.," "f. a. s.," to say nothing of "shipment in bond" or "c. i. f."

This is the common experience of business men in employing college men, with which, no doubt, all are familiar.

Usually twice during his course, the learner is given a written examination by the General Manager of Sales. The questions in these examinations are prepared by the latter and are designed to cover all the subjects with which the learner has become familiar. When these examinations are given, the learners are called together by the General Manager of Sales who explains that school days are past and each man is on his honor to do his own work without help. No supervision whatever is maintained—it is unnecessary in our experience. An examination occupies a full day's time and the answers received are illuminating. Copies of papers and answers are at hand for inspection if any one desires to look them over. The results of these examinations, with comments, are sent to each of the District Sales Managers and officials of the Company, that they may know something about the man who may some day be assigned to their office. The results with the same comments are also given to the men who took the examination. About a year ago, when a general sales agents' meeting was held, where all the district representatives were in attendance, there were three learners taking their course. Each was personally introduced to the assembled agents by the General Manager of Sales and required to give a ten minute talk on an assigned subject. It was exactly the kind of thing the man would be required to do after he had started out on the road to represent the Company, and each of the learners acquitted himself creditably.

As to compensation, while a sales learner is taking his course in the mills, he is paid $60.00 per month. When assigned to a Sales Office, he is raised to $75.00 per month and his future progress depends upon the capability he develops.

Our system is somewhat elaborate—we believe it is important. Certainly nothing can be much more advantageous to a company than to have efficient representatives carrying out its policies. When the young sales learner is first assigned to a district sales office, he is still far from being competent to handle important transactions. He has the fundamentals, however, and begins his actual work of selling by being given small and comparatively unimportant business to handle. It should be remembered that his work is then supervised by those who have themselves been trained by the same system and who, consequently, are in position

to remember its deficiencies. It is not only the learners who have learned—the company itself has improved and widened the scope of this apprentice course in the light of the results which fifteen years observation has yielded. The course is ever so much more complete than at its start.

The graduated learner, as stated, first receives assignments which are unimportant and where he cannot make costly mistakes. His work then gradually increases in importance until at the end of six months or a year of sales office work, he really starts to be of some value.

In this system of training men for its Sales Department, the entire operation is put on the highest possible plane. In any such system, the selecting of the right man is of the utmost importance. Probably not one in ten of the applications received is accepted—indeed, on the contrary, the Company has sometimes gone beyond the consideration of such applications as are received and sought out the particular man. At the present time, for example, correspondence is being conducted with the Dean of a western university regarding one particular man in the Senior Class. When a learner is employed, he is frankly dealt with. He is told that there is no gilded road to a sinecure in the steel business, and that his associations for a year or two will be far different from those to which he has probably been accustomed. It is made plain to him that his $60.00 a month salary is an investment on the part of the Company in his potential value and that he is expected to stay with the Company at least three years. But he is asked to sign no contract. His word, that it is his sincere desire to earnestly acquire a knowledge of the business, is taken as sufficient warrant of the integrity of his purpose. It is confidently believed that this system of training men is a success. Some failures have been experienced, of course, but the majority is far the other way. As previously stated, the start was made in 1900. At that time six men were admitted to the course of training. Three of those men are still with the Company, all have responsible positions, and one is the present General Manager of Sales.

PAPER NO. 1149A

TRAINING THE ENGINEERING SALESMAN

BY JOHN MEYER

(Commercial Engineer. Phila. Electric Co.)

February 20, 1915

Engineering salesmanship, so far as its relation to the Central Station industry is concerned, implies two separate and distinct features. The first, engineering, having to do with the mechanical or electrical design, or both; and second, commercial, that relating to the exchange or buying and selling of commodities for a profit.

The engineer without some commercial knowledge would be a failure as a salesman, and conversely a salesman without some engineering knowledge would be a sad failure as an engineering salesman. The success of the engineering salesman depends upon the degree with which these two elements are merged. The ideal would be a commercialized engineer.

The enormous increase of machine applications in the industries has required this type of salesman. A decade ago, the successful salesman was the one who made the most noise and spent considerable of the purchaser's time in entertainment. These factors are no longer essential. To be successful the salesman must furnish facts. The present day purchaser demands results which must be substantially measured in terms of dollars.

Considerable time and money is expended in preparing to do business. When, however, we face the problem of disposing of our product, we usually find that a very essential part of our plan has been overlooked, namely the selection of efficient salesmen. This condition prevails as well in old-established concerns.

The present plan somewhat tends to select men who have been successful salesmen in the hope that they may gain sufficient engineering knowledge to assist them in their new field. The more successful plan is to select, from the organization, men who have developed.

I will discuss the training of the engineering salesman while he is performing his function of securing business, thus paralleling this training with practical experience, from the view-point of the Central Station, with the hope that the suggestion contained therein may have practical application in other engineering industries.

Let us first give consideration to the subject matter of these studies. A national organization known nation-wide for its powerful influence in doing good recommends the adoption of the following course as one suitable to the needs of the Central Station for the education of their salesmen, that they may properly meet the requirements of their position, based on the assumption that such employees have received at least a common school education.

The subjects presented are:

SALESMANSHIP:

- Scope, Policy, and Organization of the Company,
- Fundamental Principles of Salesmanship,
- Psychology of Salesmanship,
- Contract Forms,
- Order Routine,
- Credit Information,
- Telephone Orders,
- File System for Contract Records,
- Selling Campaigns,
- Engineering Data,
- Study of Company's Advertisements,
- Public Relations.

LIGHTING SALESMAN:

- Principles of Illuminating, Illuminants, Intensity, Glare, and Distribution,
- Operation and Costs of Electric Illuminants, such as Arc, Incandescent, and Vapor,
- Relative Costs of Other Forms of Illumination,
- Lighting of Residences, Theaters, Churches, Hotels, Factories, Garages, Streets, and Spectacular Lighting,
- House Wiring Campaigns,
- Rental Propositions,
- Deferred Payment Installations,
- Signs,
- Domestic Heating Appliances.

Power Salesman:

Characteristics of Direct-current and Alternating-current Motors,
Motor Applications,
Cost of Motor Installation and Operation,
Gas and Oil Engine Competition,
Special Industries, such as Refrigeration, Storage Batteries, and Rectifiers,
Industrial Heating Appliances,
Rural Business,
Isolated Plants,
Study of Steam-Consuming Devices,
Study of the Cost of Installing, Maintaining, Operating, and Appraising Isolated Plants.

Merchandising:

Current-consuming Devices,
Method of Introduction by Central Stations,
Method of Introduction by Others, such as Department Stores, Hardware Stores, Drug Stores, Wiring Contractors, Dealers, etc.
Display Rooms, Including Office and Window Displays.

Rates:

Application of Company's Rates,
Meters and Metering, Including Measurement of Electrical Energy, Types of Watt-hour and Maximum-demand Meters, Installation Records, Accuracy Tests, and Maintenances,
Rate Adjustment,
Commission Regulations,
Franchises,
Municipal Competition.

Wiring:

Systems, such as Two and Three-wire and Convertible,
Approved Materials,
Types of Construction,
Underwriters' Rules,
City Code,
City and Company Inspections,
Estimates for Lighting and Power Installations.

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of History and Development of Electricity,
of Generating and Distribution Systems,
ve Speaking and Business Letter Writing.

ffective manner of giving these courses is by a ser- by heads and sub-heads of the various departments of the c any; by questions covering the examinations, to be ven students prior to the lecture, they to take notes for their e ns. has been found desirable to have occasional le u ties on the subject of salesmanship, and also on jec as courtesy, service, personal efficiency, health, a matters.

The m s to be pursued and the subjects to be considered depend u cal conditions, but there are certain factors we must bear in s essential to a successful conclusion. We must be impress h the fact that substantially all non-essentials have been ated, as an examination of the subject matter will show, a that the student is required to devote his attention to those matters pertinent to his activities.

The factors to which I referred are:

1st. The personal development of the salesman, that he may contribute an increasing share to the business.

2nd. A knowledge of human nature, that the salesman may adapt himself to a greater variety of men.

3rd. An intimate knowledge of the goods he has to sell and those of his competitor.

4th. A knowledge of the transaction wherein dwells the exercise of the practical act of selling—the consummation of the deal whereby property changes ownership.

The Psychology of a sales-transaction is that the purchaser's mind passes through four stages:

1st. Attention,
2nd. Interest,
3rd. Desire,
4th. Resolution.

It is that which is to be sold to which we wish to attract the customer's attention and in which we wish to arouse his interest. Any one can call upon a prospective buyer and go away again. But that is a different thing from actually securing attention.

The salesman who has won attention and can hold it and vivify it into true interest is already on the way toward persuading a customer to buy. It is also evident that the process of arousing interest, or developing it from attention, will depend on the article or goods the salesman has for his disposal. It is in his proposition that he wants the prospective purchaser to feel interest, and hence a mastery of the selling points gained by analysis will undoubtedly serve his purpose.

The salesman must create an earnest wish, longing, or aspiration for the thing he is selling. His analysis of the goods has made him familiar with all their merits and persuasive points. He has secured the customer's attention by the introduction, and, presuming this is a difficult case, he has by means of description, in his first selling talk, created a degree of interest in the goods. He has learned to present the merits of his goods in a clear and forcible manner and has so stated the points in the proposition that it already appeals to the customer in a measure. It is by driving home the points with which he aroused interest, together with the addition of fresh points, that he must strive to create desire to buy.

To sum up, reiterate some of the points brought forth to arouse interest; make these points plainer by illustration; select from analysis additional points not discussed in the other talks; bring in suggestive arguments to intensify conviction and desire. Remember that interest properly augmented will change to desire.

It is assumed that the salesman has secured attention and interest, and has created a desire, and it now remains for him to bring about the resolve to buy.

The whole purpose has been to get the customer to resolve to buy the goods, and then act. Right here is where many salesmen fall down, and much depends upon the training in class work and in the field. There are salesmen who were able to get attention, arouse interest, and even create desire, that is, it really seemed that the person to whom they were speaking desired the article, but they were unable to "close the deal." Inability to detect the "psychological moment," to recognize the instant when the customer's mind is ready to swing from desire to resolve-to-buy, is the cause of the failure of many salesmen. They cannot discern the "psychological moment." They keep right on talking and thus talk the customer into the sale and then out again. The

true salesman sees it and by immediate positive suggestions brings about decision and action.

What has so far been set forth might equally be applied to any class of engineering salesmen. The difference will be only with regard to the subject matter to be considered.

One organization has met with considerable success in developing engineering salesmen from its employees by a course of studies covering several years, and free to all employees. This course provides for class work, supplemented by home work, examination of the Company's property and operations under the guidance of heads of departments, and visitations to and discussions of the various industries. Here is combined the practical with the theoretical study. In the class work, the students are required to present their views of the subjects under discussion and are also required to prepare selling talks. It has been found that unless this method is pursued the students accumulate knowledge without being able to properly present their proposition in a persuasive and conclus ve manner.

The Class Work should be supplemented by visits to power plants and sub-stations of the Company preceding the discussion of this subject by the department heads, and this is true with regard to the study of other departments of the Company. Guides should be provided to point out to the students the more important features, to enable the students to better understand the subject when it is presented. Visits should also be made to industrial plants which should be supplemented by discussion of the particular features of the plant. The complete training that is required may be divided into three parts:

1st. Training in the principles of salesmanship.

This is accomplished by the class work, by actual demonstration in the class by experienced salesmen, by actual sales transactions between two of the students or between an experienced salesman and the sales manager.

2nd. Training in the construction and the application of the article to be sold and the results obtained by the engineering salesman who is intimately familiar with the details of the construction and operation of the apparatus.

This may be obtained to some extent by actual work in the various departments of the Company, to determine the operating condition of the apparatus the Company uses in the manufacturing of its

product; later a study of the appliances used in actual operation. As I stated before we are beyond the point where a salesman seriously enters into the sales transaction. What the purchaser desires to know is the ability of the apparatus to produce the desired result.

3rd. The training and special selling methods.
This training should be secured in class work, in the sales transactions between an experienced salesman and the prospect.

PAPER NO. 1149B

INING THE ENGINEERING SALESMAN

BY H. W. HESS

February 20, .915

Gentlemen, I alv [illegible] er peculiar in addressing a group of men who are not [illegible] ged [illegible] ordinary and theoretical work such as teaching. Moreover, it is [illegible] sing, in connection with the teaching of a subject such as advertising or salesmanship, the innumerable requests that come in connection with such varied organizations. If I did not possess considerable nerve and curiosity to find out what exists among these various groups, perhaps I would not dare venture; but, apart from any kind of information I might give you, from an academic standpoint, I am doing this apparently to get the size of different groups of minds.

I addressed a group of physicians a little while ago, and they looked upon me, I think, as a peculiar species of humanity. From an advertising standpoint, the physicians were a curiosity to me, and it may be that an individual not knowing anything about producing lights or motors will not get very much out of my talk.

Selling is a funny thing, anyhow; from the President's standpoint, the standpoint of the Executive, or from the standpoint of those who want to collect money; what a needless thing it is, anyhow, what a waste of money this selling or advertising end of it; why can we not put out our little booklets published by the Government; if we can do it, it indicates that a certain article has been put upon the market and that you can get it at the regular assigned stores. What a needless waste of effort to do otherwise. It is well to find out what is selling, so that we can feel the philosophy back of what we are trying to do. I believe that why so many people fail is because they have not a philosophy back of what they are trying to do. If there is a philosophy back of it, it is up to us to get the essence that is there to apply it, to adjust ourselves to those principles and try to create value where no value existed

before, because, when we come to an intensive analysis of salesmanship, we know that it means creating value where no value existed before. How many people go out to try to sell goods where no value existed? They do a lot of work and get to a certain point, but the man they are trying to sell to fails to give an order. We have to get back of selling enough to feel that it is a factor in economic society and that selling is a force which is necessary to bring a new article into the hands of the community. People are peculiar in their mental attitude toward salesmen. If a new thing is thrust out, we look at it with suspicion. I well remember the first automobile that went about the streets of Chicago, where I then happened to be. The people looked at the driver curiously; but we do not do that today. Advertising and effort and selling get in their work until a "vogue" exists in the community, as it did in Chicago, and the people finally concluded that an automobile was a good thing. And now the proposition is how to get the money to get the automobile. But the mere announcement that an antomobile had been invented did not sell the automobile. I understand that when gas was first introduced in London, they said that we are going to drive smoke through pipes and burn it at the other end; the people all laughed at the proposition. Now they have electricity. The first man to wear a silk hat in London was followed by a horde of men and boys all pelting him with rocks, and he was arrested for disturbing the peace. Now if you do not wear certain things you are liable to be pelted with rocks or at least ridiculed. If we had some kind of physical being with pores that absorbed all the things that we ought to absorb, we would be as gods, and we would be up yonder somewhere; but we are human; we are here bound down by instinct and tradition, and if we have a "vogue" everybody says it is "the" thing, and when people say you have reached a high state of commercial development, you have gotten "vogue." That is what you want to work for with any article you want to sell, and you want to educate the people to anything you want to sell. That is where a great many make a mistake, by thinking that the people will take it for granted. The thing you have to do is to educate the people, and perhaps you will have to call on a man fifteen times to do that. It takes weeks sometimes in order to make a man see the relationship of the thing to his business of which it is a part. A man has to know where to advertise and when to get in salesmanship.

Salesmanship is simply advertising competition. Whenever an insurance agent comes to you and talks about an endowment policy, and you have never before been talked to about insurance at all, if he tries to sell you that endowment policy right straight off, he is making a mistake. He ought to educate you on insurance first of all, and afterwards point out to you a specific policy.

Then you have to learn to differentiate between advertising and creating sentiment for a proposition and competing, in a sense that you are trying to sell him for fear that your competitor is going to get in ahead of you. The man who first made chewing gum gave it away, and people tried it and began to like it; he was educating the people to like it. And the same thing happens all over among humanity. If you stick at it you will get the same results. If there is a particular quality that has an appeal from a human standpoint, you begin to get results. But as a salesman, you have to recognize that you are talking to a particular man, and you have to take into account the particular mental state he is in at different times. I remember one summer trying to sell a sanitary bowl for optometrists. I don't know how you will explain a sanitary bowl to a convention; but you can dip your glasses down and clean them, and a lot of fellows will like it and say, well, we are coming to it; that is the idea of sanitation. Finally they would say, we will finally sweep over to it, but for the present I think we can get along without it, and the older fellows in the business are the hardest. It will take some energetic fellow to get that older individual into the notion, because the older individual is much harder to introduce it to than you think, and less susceptible to impression.

In salesmen, then, we want to recognize that fact, that the particular mental attitude that we have toward the buyer is a help towards success. There are many who do not take this factor into consideration at all.

Now there are one or two fundamental ideas I want to leave with you. First, that each field, from a selling standpoint, develops its species. We are not all on the same basis; it would be odd if we were all alike. It is possible for one species of human nature to influence another and create a much larger civilizing plan that we would have otherwise.

If you can appreciate all the detail that we have had tonight in these addresses, you will see what I mean; and yet when it comes

to getting over that particular proposition, they do not have those qualities within their nature. The man who has not the selling instinct ought not to go into that work or take up that particular vocation, and the man who does have that selling instinct ought not to get in a position where passivity exists.

Another idea, we are not expected to sell every individual that we come to. Some people think they ought to sell to every one; you are not expected to do that. Each one of us has a following in life; certain people respond to us and we respond to them. From a selling standpoint you ought to study yourself enough to know the kind of people or type of individual you can tend to influence in a given proposition, and, if you are selective, to the kind of people you will try to appeal to, and if you get one out of every ten, instead of trying to get the ten, you are going to save considerable energy. There are certain individuals who will tend to respond almost immediately, and others who will not do so at all. We have to understand that we must create a vogue, and know when to connect and absolutely drive that sale to a close. These general principles must be observed. First of all, we want to study ourselves and know our goods. We want to have absolute faith in the house we are working for, or else get in with another house if we are good salesmen. We want to recognize the fact that there is a sale between that individual and me; I have to know previously, before I approach him, all the facts concerning that man that I can possibly know. I must know even the things on his desk, the manner in which he addresses people, and the particular mood he happens to be in on that morning; I have to analyze that man, and that is the approach. Then I must get his attention, and I must not do so as many individuals do, look down on the floor and sort of talk as if you and I had analyzed the situation and of course you will have to see it. You have to transfer your personality and get the man over to your way of thinking. That sale in all of its detail must be studied, and when you are tending not to succeed it is up to you to ask the question: "Is my approach wrong, and is my demonstration not what it should be?" "Do I lack the ability to close a sale?" From an analysis from the most successful salesmen, the close should not be the most important part of the sale. The closing is the unfolding of the mental relationship that you have had with the buyer. A good many men talk themselves out of a sale that has already

been made, by continuing too long. I know of a case in point, where the salesman stated his proposition and the buyer allowed him to continue for quite a while, and after he was through the buyer said to him, you sold that to me quite a few minutes ago, there is no need to go on. You see the salesman did not understand the situation.

There is one factor that I want to call your attention to, and that is the voice, the way you use your voice, and the way you express yourself through your voice. The voice has a marvelous influence in controlling the individual. A young fellow came in to me today and tried to sell me some steel points. He started in in the most stereotyped manner in a high strained voice, and after he was through I asked him would he say it again, and I repeated that a second time, and in a little while he got down to natural tones of conversation. The thing is to know yourself and eliminate all bad tendencies at the start.

The Manager of a big concern said recently: "When I desire a salesman, there are three things I take into consideration; first, does he look me squarely in the eye; second, is he neatly dressed; and third, is his voice pleasing?" Generally speaking I think we can control our voice and express ourselves and our feelings and sympathy through the voice; certainly we have tended to do away with all negative suggestions. It seems to me from a selling standpoint alone we do not want to suggest negative thoughts and ideas. If by intensive study we can be constantly creative in trying to get a proposition over, we create an atmosphere which wins the other fellow over. Analyze your proposition as to whether you want to create a vogue, then study yourself and study the other man, and regard the whole as the scenery by means of which you will try to get the other fellow to purchase your particular article.

DISCUSSION

Mr. John C. Trautwine, Jr.—These three papers, and Mr. Gillispie's paper in particular, contrasting former and still recent with present conditions, give us a realizing sense of the phenomenal development of great industrial corporations within very recent years.

As I have often maintained here, this development is part of the great evolutionary process by which humanity is passing from the relatively pure individualism of but little more than a century ago to that completely socialized state which can hardly fail of consummation within a generation or two, so rapid and so increasingly rapid is our progress in that direction, and so irresistible are the forces urging us thither.

Mr. Gillispie mentioned that, before the recent development of salesmanship on scientific lines, the salesman was regarded, even by the manufacturers themselves, as "a necessary evil"; and Prof. Hess admitted that, from a sociological point of view, "selling is a queer thing anyway"; and, at the risk of appearing discourteous to our guests, I venture to predict that, within a half-century (thanks very largely to the activities of our great corporations), society will have reached that stage where our more nearly civilized descendants will look back with amused wonder upon these semi-barbarous days of ours, and will see that the salesman was indeed "a necessary evil," and that selling was indeed "a queer thing anyway."

Even today, it ought to be easy to recognize that, whether really necessary or not, it is an evil that the entire community is taxed to maintain great and highly organized schools, where rival armies are trained in all the refinements of a still continuing war between the rival industrial armies, still maintained by the corporations, in default of that public industrial army into which these warring tribes must before long be merged.

Mr. Meyer noted the four successive stages (1, attention; 2, interest; 3, desire; and 4, action) to which the victim must be brought by the salesman who hopes to outwit his competitors and land the one thing needful—*The Order.*

Mr. Gillispie has mentioned that the student of salesmanship is encouraged to familiarize himself with the products of competing manufacturers. Is this in order that, when the customer is trembling on the brink which separates (3) desire from (4) action, the salesman is encouraged to begin dilating upon those points in which he knows his competitor's product to be superior to his own wares?

Prof. Hess mentioned the value which salesmanship is supposed to "create" by hastening the general use of inventions (he mentioned the automobile as an instance) which, otherwise, might have come more slowly into general use. He contrasted the activity of the automobile salesman with the modest silence of our general government respecting its own products. This calls to mind the topographic sheets published by the U. S. Geological Survey, and sold for perhaps less than one-twentieth of the price at which any private producer could afford to sell them. The fact that they are for sale for nearly nothing is pretty generally known to those who would be likely to make use of them; and they thus, practically without salesmanship, find the sale which the conditions warrant. Would it be better if government salesman went about the land unloading these maps upon reluctant farmers and milliners, and is it an unmixed blessing that thousands of our citizens have been led, by the salesman's art, to mortgage their all for automobiles without which, perhaps, they would have been better off?

Prof. Hess mentioned the distrust with which new inventions are regarded, and with which the salesman is usually welcomed into the office of the intended victim. I lately addressed the Jovian Electrical League upon the subject of "Sin, as a Symptom of Maladjustment," and Emerson reminds us that the presence of that "obscene bird," fear, surely points to the existence of carrion in the neighborhood. We distrust the salesman just because we know that he has been trained in a school whose express purpose is to teach him the noble art of giving a one-sided view to the question at hand. Distrust is the necessary outcome and symptom of a "business system" which puts its premium upon

"doing" one's fellow-man, and which develops the salesman as the paid instrument in this noble work.

One of the gentlemen who discussed the papers mentioned the art of buying. Our guests will doubtless agree with me that the buyer is merely an inverted salesman. The salesman seeks to induce you to part with your money for his wares; the buyer seeks to induce you to part with your wares for his money. Now, as there is no question as to the value of the money involved in either case, the arts of the positive or negative salesman (the "salesman" or the "buyer") are devoted to changing the mental attitude of the victim respecting the value of the wares involved. The positive salesman seeks to exalt his customer's estimate of the value of the goods which the salesman has to sell. The negative salesman (or "buyer") seeks to convince the owner that his wares are of less value than he thought. This is the underlying principle of both positive and negative salesmanship; and I recall a text, from the book of Proverbs, which shows that this principle was known thousands of years ago.

This brief text, of only seventeen words, describes, with clearness and completeness, the operation of the buyer, in depreciating his victim's wares, and his rejoicing when he has brought that victim to Mr. Meyer's "stage 4," the stage of action:

"It is naught, it is naught, saith the buyer; and when he goeth his way, he rejoiceth."

Mr. J. Frank Dechant. I was in hopes I would not be called upon to take the attitude of criticizing, and yet I feel as though I would like to make some remarks in a constructive way. I enjoyed every one of the talks and got a lot out of them. As you know, there is an old statement so often repeated and referred to, that a salesman is born and not made, but the large corporations are spending lots of money in training and making the fellow who is born that he may become a better salesman. I think we are coming to the time when the salesman will be given a title such as "Doctor of Salesmanship" just as an engineer or a doctor or a lawyer is given a title. When we come to a scientific analysis of salesmanship no doubt we will be driven to give titles. Mr. Meyer is one of our students, and naturally, being trained along the same lines which I have been trained, we look at these matters in pretty much the same way. We did not realize at first the importance of getting favorable attention, or, in other words, vibrating with the person to whom we are talking. There are ways and means of doing this. One way is doing the unusual constructive thing. One of our students was recently assigned to go through the Western country with a new line of stationery, and he called on a big fellow in the West, thinking to sell to him first and get him as a reference; but the big dealer met him with the statement that "we are using all that kind of material we want, and we do not want to be bothered with a new line," refusing even to look at his samples. This fellow went back to his hotel and gave the matter some deep and careful thought. He said to himself, "there must be something wrong with me; what is it?" The first thing he did was to take a bath; then he put on clean underwear, a clean shirt, a clean collar, everything—an entire change of clothing, and then he went back to the big dealer. He said: "Mr. ———, there was something wrong with me when I called on you this morning, and—" well, he told him what he had done, and he said, "now will you favor me by taking a look at my samples?" And

the big man was very much pleased. He said "My, I wish my salesmen would be willing to go to all that trouble for me—certainly I will look at our goods."

The salesman knew he had to do something unusual to get favorable attention, and for the lack of that principle many sales are lost. When he gets favorable attention, as Mr. Meyer stated, his battle is almost won. Nature's laws are mighty, and that is just as absolutely a law as the law of gravitation, namely, favorable attention secured by doing the unusual thing in a constructive way. If you cannot get it that way, there is one thing that does get attention, and that is the personality of a man.

One other thing I want to say; that is, that salesmanship is going to be more a matter of rendering service. The essence of salesmanship is the power to serve to the end of the satisfaction of the buyer and the seller. As soon as you show the salesman that he has something by which he can render a service, the greater will his success be. We ought to begin to eliminate the thought of competition and think more about what to do to render this man a service. If I can render a better service I do not need to bother much about competition.

Mr. J. C. Parker.—A few years ago I visited a large manufacturing plant in Ohio, the president of which was quoted as saying that selling goods was 90 per cent of the business, and that the making of them was only 10 per cent. The guide stated that their Los Angeles representative had made something like $20,000 the previous year, and another who received $35,000 for the year. After telling the visitors that salesmanship represented 90 per cent of the endeavor, and construction only 10 per cent, he led them to the basement, and pointed out a lot of scrapped machines that had been sent back from Europe—$50,000 worth. When these were received the President of the Company said we will have to get engineers and workmen equal to the European engineers and workmen. They put inventors and engineers to work and soon produced machines that would do all that the European machines would do, and more, and then the salesmen in Europe were able to sell goods which would *stay sold*. Recently the President of this concern was convicted for overdoing salesmanship. It seems to me there is a tendency among some business people today to magnify salesmanship at the expense of engineering. Does this experience in Ohio show that salesmanship is 90% of the business? Do not engineers who make better things or more sufficient apparatus provide the fundamental reason for the sale of them?

Mr. John I. Rogers.—You say "Salesmen are born, not made" and I have been much interested in the talk about the education of the engineering salesmen. These large companies have a very interesting and extensive system of training salesmen which smaller concerns could not possibly have and therefore the smaller concerns have to train their salesmen along different lines, or take salesmen who have formerly worked for the larger companies, and thus get the benefit of their previous training. Most of the engineering salesmen that I have had experience with are very well educated, especially in the technical line of what they are selling. I think it is much easier to make an engineering salesman out of an engineer than it is to make an engineering salesman out of a plain salesman.

Where a great many companies are at fault is in the purchasing end. The salesmen seem to have been educated in the best possible way to explain to the

customer what is best for his needs and to satisfy him. A great many purchasing agents have learned what their company needs, but there are a great many, more or less ignorant, who only look at getting the lowest price so could not realize what is best for their company. In the end I think if large companies would put their purchasing agents through the same course of training as that through which they put their salesmen that it would be of very great benefit.

In regard to knocking one's competitor, I think that is growing less and less each year, and I think the salesman who does it is looked down upon immediately. This point reminds me of the story of the purchasing agent who was about to place the contract for his leather belting. One morning he received visits of a dozen or more firms; he listened to each one, telling each one that he desired to split his contract, giving part to one concern and part to another, and asked one's advice as to what other concern he should give the other part of the contract to if he gave the one part to the concern that that one represented. Each one of the salesman stated that after his concern the next best was so and so, and as this one each recommended in the second place by all of them happened to be the same with all, the agent decided that they must be the best and awarded the whole contract to the one they recommended for second place.

When a man comes in to sell goods, he does not come to get just one order but comes to establish himself and one of the greatest things to get a customer to do is to make him get the habit of ordering from you.

Mr. Chas. H. Bigelow.—One thing the engineering salesman runs up against is that he does not always arrive at the psychological moment; the article that he has may be something that will be required a little later, but at present the prospective customer is busy with other work and has not time, even if he wanted to, to discuss things that will not be required for months and on which the details have not been worked out. I am referring particularly to construction work. The best thing, in this case, for the salesman is to state briefly what he has and arrange to call later.

Another trouble, especially with the younger men, is that they are too inclined to state that they have never heard of any trouble or complaint of their particular article, if the question is asked, and this can only be put down to one of two things; either the complaints are very carefully kept from them or else they are, to say the least, stretching the truth.

The speaker has had a good many years' experience with the purchase and operation of mechanical appliances of all kinds and he has yet to find the perfect article, and he believes it is far better for the salesman to be truthful and state the weak points as well as the good ones, so that the customer will know what to look out for, than to try to make the customer believe that his article is perfect and fool proof and that it will never wear out or give trouble.

Of course, the trouble is not always reported and the article is often thrown out, particularly if it has been bought and paid for, without notifying the manufacturers as that often means more or less discussion without any satisfaction. In fact, the speaker has known cases in which concerns have advised that their apparatus was used by companies long after it was in the junk pile.

Only the other day I was looking up the question of purchasing a piece of apparatus and went to the factory to see it. I asked particularly what troubles would be expected with this apparatus, and was told of those as well as the

good points. The good points overbalanced the trouble, however, and that piece of apparatus was purchased, but we know about what trouble to provide for and trust that it will give satisfaction.

Mr. R. Geo. Ward.—I cannot speak from the standpoint of the college salesman. I came to this country about ten years ago and landed in New York without practically any friends, and I always had it in my head that I could sell goods. I took a job at ten dollars a week, and I remember applying for a job as salesman, and in an interview with the General Manager of the Sales Department he said "What do you know in regard to the application of steam specialties in power plant equipment?" I said "I do not know anything about your business, but if you will accord me the privilege of going into your factory to see what I can do, and then send me out, I believe I can make some showing." So they did. Twenty-two men applied for that position, and in nine months they sent me down here as Manager of their Philadelphia Office.

A few weeks after arriving in Philadelphia I had an experience that I shall never forget. I had to go to see the Chief Engineer of a concern. This man was well known for the extensiveness of his vocabulary. He graduated from a university, and the more swearing he could do the better he liked it. I knew if I sent in my card I would not get an interview, so I followed my card very closely, and seeing the gentlemen was not engaged I walked in. The first thing he told me was to go to the hot place. But I leaned over his desk and said, instead of going to a place where they keep automatic stokers, I want to make a test to demonstrate that my goods are equal to what you are using, and if they are, I want an opportunity to get a contract for the goods that we want to sell. That man gave me my opportunity in Philadelphia.

I have worked hard on certain propositions, and I have often wondered why I could not sell to certain people. I have studied the men from every angle, and yet in certain cases I have not been able to sell. There may be various reasons for that. Our personality may not appeal to a prospective buyer, and, as Mr. Hess said, our thoughts may not run in the same channel.

I think I have learned something tonight as to what to do with the goods I have in mind for next week.

Mr. H. V. Schreiber.—It is interesting to compare the methods of training salesmen used by the companies with which the first two speakers are connected. The first speaker laid special stress on the special detailed technical knowledge of his salesmen who handled a class of products the qualities and manufacture of which the salesmen must know thoroughly. The second indicated how a man could be trained in the principles of salesmanship; having the technical knowledge of the product as a part of his previous education, he needs to be taught the way to dispose of his product.

Much of the merit of the methods described by electric lighting and power companies is doubtless due to the long continued and now highly developed work of the National Electric Light Association. Co-operation in many problems of both manufacture and sales by companies naturally non-competent has proved of wonderful benefit and should be a good example to manufacturing companies in many lines where co-operation is possible along lines that may not seen practical at first.

The subject of salesmanship is of interest to our members because sales problems are confronting us all. They may be the disposal of a manually or mechanically manufactured product or a mental product. If we have nothing else to sell, we have ideas, suggestions, or orders which we wish to sell our superiors or inferiors. If we want to have our product accepted voluntarily and make successfully the fifth step in any sale we must see that it produces satisfaction so it will stay sold and so we can sell again. We cannot expect co-operation of co-workers where our ideas, plans, or policies have not been properly and fully sold. This phase of the science of salesmanship may be worth our further study.

Coming back to the practice of these two companies it would be interesting no doubt to compare the make-up of the standard books of instructions for salesmen. To compare the subjects handled, the methods of testing to determine the value of each portion of the time spent by the men and cash invested by the company. One company must invest some $2000 or more per man, before any real returns begin, yet this is done without any formal contract, and with no opportunity to make many practical tests to see if the investment is made in men who will meet the road conditions satisfactorily. The second sells to a home market only and there is ample opportunity to try out men during their development, follow up their work, and note whether they are getting what they need out of their instructions.

Mr. J. E. Gibson.—I think that an engineering salesman should thoroughly acquaint himself with his competitor's goods and be prepared when asked by prospective customer to give him a truthful statement of facts.

I have in mind a salesman for whom I have great respect, who had the Chief Engineer of his Company come on and consult with a prospective customer's engineers. The salesman and engineer were very broad-minded and pointed out to the prospective customer the probable difficulties that would be met with in the installation of the proposed machinery manufactured by them and the points of merits of their competitor's goods. The result was that the customer did not purchase the said salesman's material but did purchase the competitor's material.

This on the face appears to be anything but good salesmanship, but I think it was the highest type of salesmanship, and it actually increased the regard of the customer for this salesman and he has been given many orders since that time.

Mr. John Meyer.—I am rather surprised that there is such a difference of opinion. I do not believe we can do without the engineer any more than we can do without the salesman. I do not think it is advisable to employ dishonest engineers any more than it is to employ dishonest salesmen, because the people will find it out and drive you out of the field. In the electrical industry there was a difference of opinion between the commercial men and the engineers, and it was not until the commercial men came into their own that proper progress was made in the electrical industry. The great efficiencies that are produced in central stations today are due to that fact. The question has been raised as to the desirability of the class work. It is surprising the number of good ideas that are brought out in the class and given to

the engineers, and which they make use of, and today they welcome the opportunity to meet with the commercial men. In our own Company we have an organization that is a branch of a very large national organization, where we get together monthly. Probably 50% of the membership of that organization get together monthly to discuss ways and means of doing things right. In addition to the main meeting there are three branch meetings, and they each evolve their problems. We in the main meeting then attempt to solve these minor problems.

In regard to the salesman. If he were to study with attention the four factors that have been read, and follow them through to the resolve to buy, probably he might secure that which we are trying to secure—the sale of the goods. That is not mere guessing ability in our case.

Mr. Trautwine has discussed, I think, the sting or the bite. It is true that people are being bitten today, and it is pitiable. It makes it more difficult for the honest salesman to sell his goods. It is singular, too, that the biting continues, and I think the biting in the salesman field will continue for some time to come, and I believe you men can help us to wipe out these difficulties.

ABSTRACT OF MINUTES OF THE BOARD OF DIRECTORS

ORGANIZATION AND REGULAR MEETING, FEBRUARY 16, 1915

Present: President Ledoux, Vice Presidents Vogleson and Yarnall, Directors Gibson, Hibbs, Wagner, Worley, Dauner, Dunlap, Bonine, Irish, Jones, Wilson, and the Treasurer.

The President announced the appointment of the following Committees for the year 1915:

HOUSE—F. K. Worley, J. H. M. Andrews, J. A. Vogleson, G. S. Cheyney, and Herbert Rice.

MEETINGS—J. C. Wagner, C. E. Bonine, J. E. Gibson, Morris L. Cooke, and Charles Day.

FINANCE—William M. Irish, J. R. Bailey, H. A. Moore, Henry Hess, and B. A. Haldeman.

MEMBERSHIP—J. R. Gibson, Manton E. Hibbs, F. C. Dunlap, H. F. Sanville, and John C. Trautwine, Jr.

PUBLICATION—Manton E. Hibbs, J. Chester Wilson, Jonathan Jones, W. R. McLain, and H. Clyde Snook.

PUBLICITY—Same as the Publication Committee.

LIBRARY—F. C. Dunlap, E. J. Dauner, Jonathan Jones, John S. Ely, and Charles F. Puff.

PUBLIC RELATIONS—S. M. Swaab, Coleman Sellers, Jr., W. P. Taylor, John C. Trautwine, Jr., Carl Hering, H. H. Quimby, Edgar Marburg, John Birkinbine, Walt Clark, S. M. Vauclain, William Easby, Jr., Henry Hess, Thomas C ıcBride, and H. M. Chance.

INCREASE OF MEM .RSHIP—A. C. Wood, Joseph T. Richards, Carleton E. Davis, Henry Hess, Robert H. Fernald, Richard L. Humphrey, Emmett B. Carter, D. Robert Yarnall, and S. M. Swaab.

The following resignations were accepted as of December 31, 1914, and the Treasurer authorized to strike from the books the dues of those members who had been charged for the year 1915: Harry Bortin, Charles H. Cox, Henry J. Edsall, S. W. Evans, J. J. Gartland, Jr., J. J. Gibson, Henry E. Hayward, D. A. Hegarty, J. Russell Hibbs, F. N. Morton, W. L. Plack, W. T. Pringle, C. R. Rothwell, Fletcher Schaum, Wm. C. H. Slagle, George R. Stearns, Ernest A. Sterling, Edgar Stilley, Charles R. Weiss, James S. Watson, John J. Young, Jr., J. C. Ziegler.

The Treasurer reported a net gain of $168.01, as compared to a net loss for the preceding year of $95.72.

The House Committee's report was presented and accepted, and the purchase of the pocket billiard table was confirmed.

Report of the Membership Committee was presented and the following elected:

To Active Membership—H. S. Goodwin, Eberhard Henriksson, Arthur C. Toner, W. W. Haughey.

Mr. Gibson reported for the special committee on water supply in the Club house, and recommended that new risers for the hot and cold water be installed in the front and back of the building with a laundry heater and reserve tank to relieve the present unsatisfactory conditions in the water supply. Appropriation not to exceed $350.00 was made to this Committee, which is to cooperate with the House Committee in the installation of these additions.

The Treasurer reported a list of members to be dropped, and he was authorized to strike from the rolls all those members delinquent for one year or more. The list comprises the following: C. K. Brown, Harold E. Brunner, W. I. Cheyney, L. P. Clark, W. L. Clayton, Charles J. Corr, John N. Costello, James E. Diamond, Charles L. Downs, Thomas M. Eynon, Hugh P. Fell, Richard B. Ferris, William H. Ford, J. Grier Foresman, Frank E. Hahn, Walter S. Hine, H. W. Huntzinger, A. M. Loudenslager, W. K. Mitchell, George K. Myers, David M. Niver, Harold S. Pierce, John A. Robb, Robert F. Runge, C. Carroll Sloan, F. F. Waechter.

Mr. Yarnall reported on the progress of the Engineering Co-operative Movement.

Communication from the Philadelphia Section of the Massachusetts Institute of Technology was referred to the Executive Committee of the Engineering Co-operative Movement, with power to act.

The question of renewing the first mortgage, which expires December 26, 1915, was referred to the Finance Committee.

A communication from the American Publicity Bureau was referred to the Publicity Committee.

The Finance Committee was requested to prepare a budget to be presented at the next meeting of the Board.

REGULAR MEETING, MARCH 16, 1915

Present: President Ledoux, Directors Gibson, Hibbs, Wagner, Andrews Dauner, Dunlap, Bonine, Irish, Jones, and the Secretary.

The minutes of the Regular Meeting of February 16 were read and approved.

The Secretary reported the resignation of J. A. MacLennan, which was accepted as of December 31, 1914.

The Treasurer reported a net gain of $142.92 to March 1, as compared with a net gain of $17.55 for the same period of 1914.

Report of the Finance Committee was submitted and the various Committees were instructed to prepare a detailed budget to be presented to the Finance Committee at the earliest possible date.

Reports of the House, Membership, and Publication Committees were presented and approved.

The following Tellers and Alternate Tellers were appointed by the Board for the year 1915:

Tellers: John S. Ely, George W. Hyde, Joseph W. Silliman.

Alternates: H. P. Gant, Thomas M. Chance, Charles Elcock.

The Secretary announced the death, on January 16, 1915, of William Penn Evans. The Publication Committee was instructed to prepare a suitable memorial for publication in the Proceedings.

SPECIAL MEETING, MARCH 29, 1915

Present: President Ledoux, Vice Presidents Snook and Yarnall, Directors Gibson, Wagner, Worley, Dauner, Wilson, Bonine, Jones, and the Secretary.

The Executive Committee of the Affiliated Societies was represented by Mr. Taylor, Dr. Hering, and Dr. Marburg.

Dr. Marburg, speaking for the Committee, explained the differences that need to be reconciled as a consequence of the adoption of the amendments to the By-Laws on March 20, 1915. After considerable discussion, the following resolution was presented and adopted:

> *Resolved,* That it is the sense of this meeting of the Board of Directors that the reorganization of the Engineers' Club in accordance with the revised By-Laws in their latest amended form should be effected as soon as possible, and further, that a Committee of Seven be appointed at once, composed of three (3) members of the Board and the Chairman of each of the affiliated organizations: viz., A.S.M.E., A.I.E.E., A.S.C.E., I.E.S., to prepare a report and submit a definite and complete proposed form of procedure in detail at the next stated meeting of the Board, April 13.

The President appointed Messrs. Yarnall, Snook, and Vogleson, in accordance with the intent of the resolution, and asked the Chairman of each of the affiliated organizations (A.S.M.E., A.I.E.E., A.S.C.E., and I.E.S.) to act with this Committee and prepare a report, in accordance with the resolution.

REGULAR MEETING, APRIL 13, 1915

Present: President Ledoux, Vice Presidents Vogleson and Yarnall, Directors Gibson, Wagner, Worley, Andrews, Dauner, Dunlap, Moore, Bonine, Irish, Jones, Wilson, the Secretary, and the Treasurer.

The minutes of the Regular Meeting of March 16 and the Special Meeting of March 29 were read and approved.

The Treasurer reported a net gain of $102.56 to April 1, as compare with a net loss of $37.17 for the same period of 1914.

Report of the Membership Committee was presented and the following elected: To Active Membership—Maxwell F. Gilbert, Charles F. Iszard, William Van Kleeck, Frank N. Kneas, William L. Wall, Howard N. Wells; To Junior Membership—Ezra Garforth.

The report of the Special Committee on Water Supply was presented, their bills approved, and the Committee discharged with thanks.

Report of the Special Committee for devising ways and means of placing the new By-Laws into operation presented its report, which was unanimously accepted.

The following resolution was adopted, to be inserted in the minutes of the meeting and signed by each Director:

> *Resolved,* that for the year beginning May, 1915, and ending May, 1916, the present Directors of the Club shall continue in office, but shall act as a unit, so that a majority of such Directors present at any meeting shall have the power of casting but one vote upon any question, whenever any representative of an Affiliated Organization on the Board so requests.

At the Annual Meeting in May, 1916, the whole present Board will retire from office and one or more Directors-at-large shall be elected to conform with Section 6 of the By-Laws. Should any one of the said Directors die, resign, or cease to be members of the Club during the said Club year, the vacancy so caused shall not be filled, but the remaining members of the Board shall continue to act as above provided for.

In addition to the resolution submitted by the Special Committee, the following recommendations were made and approved by the Board:

First, that no changes be made in the personnel of any of the standing Committees (Finance, Membership, House, Publication, and Meetings), except the Meetings Committee, and of this, the Chairman should remain, and the Chairman of the Publication Committee should remain. The places of the other members of this Committee should be filled in accordance with the new By-Laws.

Second, all other Committees should be asked for a report and discharged (Public Relations, By-Laws, and Increase of Membership).

The Philadelphia Section of the American Institute of Electrical Engineers, the Philadelphia Chapter of the American Society of Mechanical Engineers, and the Philadelphia Chapter of the Illuminating Engineering Society were elected to Affiliated Membership.

The application for Affiliated Membership in the Club of the American Society of Engineers, Architects, and Constructors was presented. It was moved and carried that the application be referred to the Membership Committee.

After considerable discussion, it was moved and carried that the present Meetings Committee be designated the Papers Committee, with the duties remaining the same, the Chairman of the Papers Committee to be the Chairman of the Meetings Committee, in accordance with the provisions of our new By-Laws.

Mr. Washington Devereux was appointed delegate to represent the Engineers' Club at the Convention of the National Fire Protection Association.

Mr. J. H. M. Andrews and Mr. Charles F. Mebus were appointed delegates to represent the Engineers' Club at the election of Trustees at Pennsylvania State College.

Communication was received from the Committee on Public Relations and the following resolution was ordered to be presented to the Club at its Regular Meeting on April 17:

WHEREAS, a movement is now on foot to form a comprehensive organization for the development of the commercial interests of Philadelphia, and

WHEREAS, the scattering of effort among a number of organizations having similar or nearly similar objects is detrimental to efficiency; therefore be it

Resolved, that the Engineers' Club of Philadelphia views with sympathy and satisfaction the movement looking to the co-operation of commercial interests of the city through the creation of a "greater Chamber of Commerce."

The application of the National Safety Council for the use of the meeting room was presented to the Board. It was moved and carried that the Secretary be instructed to reply to the application to the effect that the practical

of the Club were such that the requests could not be granted, e of the auditorium could be placed at the disposal of the Society rs at a charge of $10.00 per night and $3.00 extra for the use of n; and, furthermore, that the Board expresses its approval of the ade by this organization to further the cause of safety and san-

ABSTRACT OF MINUTES OF THE CLUB

JOINT MEETING, JANUARY 16, 1915,

of the American Institute of Architects, Philadelphia Chapter, and the Engineers' Club of Philadelphia.

The meeting was called to order by Vice President Mebus at 8.30 P. M., with 127 members and visitors in attendance. After welcoming the Philadelphia Chapter of Architects, Mr. Mebus relinquished the chair to Mr. Percy L. Madeira, chairman of the Philadelphia Chapter, who introduced the speaker of the evening.

Mr. Walter H. Cook, Past President of the American Institute of Architects, presented a paper entitled, "The Present Tendencies of Development in American Architecture."

Mr. Grosvenor Atterbury, Secretary of the Russell Sage Foundation, presented a paper entitled, "Working Men's Homes."

Dr. Carol Aronovici, Messrs. Leffmann, Maignen, and Jones discussed the papers.

SPECIAL MEETING, JANUARY 19, 1915

The meeting was called to order by President Swaab, at 8.40 P. M., with 53 members and visitors in attendance.

Mr. W. A. Blonck presented the paper of the evening entitled, "European Boiler Room Practice and Boiler Efficiency Methods in U. S. A., with Reference to Electric Light and Power Plants."

37TH ANNUAL MEETING, FEBRUARY 6, 1915

The Meeting was called to order by President Swaab at 8.40 P. M. with 112 members and visitors in attendance.

Minutes of the joint meeting of the American Institute of Architects, Philadelphia Chapter, and the Engineers' Club held Saturday, January 16, 1915, were approved as printed in abstract.

Proposed amendments to the By-Laws were submitted signed by the following active menbers: D. Robert Yarnall, W. P. Taylor, Carl Hering, Fred C. Dunlap, W. Copeland Furber, Henry Hess, S. M. Swaab, Charles F. Mebus, H. L. McMillan, Manton E. Hibbs, B. A. Haldeman. The president announced that in accordance with the By-Laws these proposed amendments will be brought up for discussion and further amendment Saturday, March 6, 1915, and if accepted will then be formally acted upon Saturday, March 20, 1915.

Vice President Mebus then took the Chair and President Swaab presented the paper of the evening entitled "The Fundamental Elements Entering into the Makeup of the Modern City and a Plea for a Smaller City."

The tellers announced that 81 legal ballots had been cast and the following elected to office: President, J. W. Ledoux; Vice President, D. Robert Yarnall; Secretary, Lewis H. Kenney; Treasurer, J. Reese Bailey; Directors, Charles E. Bonine, William M. Irish, Jonathan Jones, J. Chester Wilson.

Mr. Swaab made the following remarks and introduced the new President, Mr. J. W. Ledoux.

"In the address delivered by me on the occasion of my assuming the office of President of this Club, I made the statement that I would endeavor to uphold and further the high standard as a technical institution that had been maintained by the Club for many years, and I also expressed myself to the effect that, when twelve months from the date of my induction into that office I surrendered it to my successor, its luster would not be dimmed not its usefulness impaired, and I trust that I have lived up to this pronouncement. I wish to call your attention at this time, as I did on that occasion, to the fact that the success of this institution, like that of any other, is dependent on the live interest shown in its affairs, not alone by its officers, but by the membership at large as well. What I wish to emphasize is that what Micawber called "waiting for something to turn up," or the process that is now designated "watchful waiting," while it may or may not be an efficient means of handling an armed insurrection in a neighboring state, is not conducive to materially advancing the interests of a technical or scientific society. I am of the opinion that to attempt at this time to consider our material condition would be superfluous, as the condition of affairs in the country today is so well known as to be apparent to every one. Whether this condition has been brought about by the industrial depression which followed the outbreak of the European War, which depression followed closely on another caused, many think, by governmental interference in semi-public and private business, or whether it is a psychological condition, as President Wilson has called it, means very little. Suffice it to say, in the language of the revered Grover Cleveland, 'it is a condition and not a theory that confronts us.'

"Ninety per cent. of all the engineers in this country are said to be employees, and probably in this Club as great, if not a greater percentage, are employees rather than employers; and in these troublous times of necessity many have to retrench. This principle of retrenchment has been practiced not alone by individuals but by large corporations as well, and, unfortunately, at this time many engineers are without employment, and this has no doubt considerable to do with our present status. Let me express the hope that with the betterment of our industrial conditions and the end of the war, which I trust will not be far distant, will come the much needed opportunity to expand; with industrial peace in this country as well as peace among the nations of Europe will come progress and prosperity and then our organization will come in for its share.

"One word as to the amalgamation or federation of Engineering Organizations which has been proposed and has been all but consummated during the past year. This movement was conceived as long ago as the year 1903, when on the occasion of the 25th anniversary of the birth of this Club it seems to have been first suggested, but it never materialized and it slumbered on and had almost expired. Not to follow all of its vicissitudes, suffice it to say that within the past year it was revived with much vim and gusto, and a new impetus given it. The sane and sober and intelligent work expended on the exploitation of

this movement by the Executive Committee has rejuvenated it, and we hope it will blossom into maturity in the very near future. The tendency of the times is towards conservation. Concentration and central control are necessary for efficiency and economic administration of all organizations, whether commercial or otherwise. The movement is therefore a natural concomitant of the heretofore existent conditions and is in keeping with the highest ideals and traditions of our times. It is my earnest desire that we may all live to see the accomplishment of this movement which cannot but make for our good.

"I wish to thank the officers of the Club for their intelligent and earnest support during the last year, during only a part of which I was allowed the high privilege of presiding over the Club, owing to a severe physical disability contracted prior to my election to the Presidency. I wish also to express my sincere thanks to the Club membership at large for their approval of the course steered by the Board, which, although it has been tortuous at times, has always made for the material advancement of the Club; and last but not least let me say that the loyalty, faithfulness, intelligence, and devotion to duty of the employees of the Club deserves and receives my heartiest commendation.

"I am privileged to introduce to you my successor in office, Mr. John W. Ledoux."

REGULAR MEETING, FEBRUARY 20, 1915

Meeting was called to order by President Ledoux at 8.30 P. M. with 117 members and visitors in attendance.

Secretary announced the election of H. S. Goodwin, Eberhard Henriksson, Arthur C. Toner, and W. W. Haughey to active membership.

Messrs. R. L. Gillispie, John Meyer, and Herbert W. Hess addressed the Club on "Training the Engineering Salesman."

Messrs. J. C. Trautwine, Jr., W. R. McLain, J. Frank Dechant, and H. V. Schreiber participated in the discussion.

BUSINESS MEETING, MARCH 6, 1915

Meeting was called to order by President Ledoux at 8.15 P. M. with 97 members and visitors in attendance.

The Amendments to the By-Laws were discussed, amended, and ordered sent to the members for ballot.

Mr. Oliver Randolph Parry presented the paper of the evening entitled "The Use of Reinforced Concrete and Hollow Tile in Dwelling House Construction."

Messrs. Swaab, Hibbs, and Boorman discussed the paper.

BUSINESS MEETING, MARCH 20, 1915

Meeting was called to order by President Ledoux at 8.35 P. M. with 81 members and visitors in attendance.

Mr. Howard W. Du Bois presented the paper of the evening entitled "Concentration of Ores by Oil" which was discussed by Messrs. Maignen, Hering, Cambe, Klotz, Chance, and Keith.

Following his paper, Mr. Du Bois showed some wonderful stereopticon views of Alaska.

The President read the report of the Tellers on the Amendments to the By-Laws, which showed that 74 legal ballots had been cast, 70 for and 4 against the amendments.

SPECIAL MEETING, MARCH 22, 1915

Meeting was called to order by Vice President Yarnall at 8.25 P. M. with 97 members and visitors in attendance.

Mr. Emmett B. Carter gave an illustrated lecture on the Panama-Pacific Exposition.

REGULAR MEETING, APRIL 3, 1915

The meeting was called to order by President Ledoux at 8.35 P. M. with 57 members and visitors in attendance.

Hon. A. Merritt Taylor, Director of Department of City Transit, presented the paper of the evening, entitled, "Philadelphia's Transit Problem," which was discussed by Messrs. Nichols, Hering, Chance, Du Bois, and others.

JOINT MEETING, APRIL 20, 1915

The American Society of Marine Draftsmen, Delaware River Branch, and the Engineers' Club.

The meeting was called to order by Vice President Yarnall at 8.30 P. M. with 107 visitors and members in attendance.

The minutes of the Special Meeting of the Club held Monday, March 22, 1915, and the regular meeting of the Club held Saturday, April 3, 1915 were approved as printed in abstract.

The Secretary announced that the Board of Directors at a regular meeting held Tuesday, April 13, 1915, had elected to membership the following: To Active Membership: Maxwell F. Gilbert, Charles F. Iszard, William Van Kleeck, Frank N. Kneas, William L. Wall, Howard N. Wells. To Junior Membership: Ezra Garforth.

The following resolution was presented and the chair announced that the resolution would be acted upon at the next regular meeting, May 1, 1915:

> WHEREAS, a movement is now on foot to form a comprehensive organization for the development of the commercial interests of Philadelphia, and
>
> WHEREAS, the scattering of effort among a number of organizations having similar or nearly similar objects is detrimental to efficiency; therefore be it
>
> *Resolved*, that the Engineers' Club of Philadelphia views with sympathy and satisfaction the movement looking to the co-operation of commercial interests of the City through the creation of a "Greater Chamber of Commerce."

Rear Admiral Joseph Strauss, Chief of Bureau of Ordnance, U. S. N., presented the paper of the evening, entitled "Ordnance Engineering," which was discussed by Messrs. Yarnall, Furber, Carter, Tawersy, Rogers, Nichols, Swaab, Watters, and Maignen.

ST. GEORGE HENRY COOKE

The death of Captain St. George Henry Cooke removes from the Club rolls one of the most prominent and promising of its younger members and leaves to mourn his loss a large circle of friends to whom he had endeared himself.

St. George Henry Cooke, son of Rear Admiral George H. Cooke, U. S. N., retired, was born in Philadelphia, Penna., June 2, 1883. He was graduated with the degree of C. E. from Pennsylvania Military College, Chester, Pa., June 18, 1902, and immediately thereafter entered the employ of Roydhouse Arey and Co. He successfully supervised construction work for this firm in Philadelphia and Altoona until December, 1905, when he severed his connection to accept a position as Assistant Engineer in connection with the construction of the Tidewater Railway Co. Here he remained until January, 1908, when he opened an office in Chester, Pa., subsequently moving it to Philadelphia, where he continued to transact a consulting business until ill health forced his retirement from active pursuits.

A man of unusually promising professional attainments, he is best known to the Club membership for his connection with the successful military organization which represents the Club in the National Guard of Pennsylvania. On January 8, 1909, this organization, composed of Club members, was mustered into the service of the Commonwealth as Co. "B" Engineer Battalion, N. G. P., and Captain Cooke was unanimously chosen as its Commanding Officer. Military by instinct he threw himself with energy and enthusiasm into the work of organization and training. So marked was the success of his efforts that the Company soon took rank among the leading units in the State service and gained for its commanding officer the official approbation of the U. S. War Dept., as "an officer eminently fitted for command."

Elected to the Engineers' Club as a junior member, Feb. 20, 1904, he was transferred to Active membership Dec. 31, 1908, and served as Director from January, 1911, until March, 1913. Captain Cooke was also an Associate Member, American Society of Civil Engineers; American Society of Mechanical Engineers, and was a member of the Military Order of the Loyal Legion.

Suddenly stricken in the midst of his activities in July, 1912, he made a long and brave fight against the encroachments of disease. A short residence at Saranac Lake, N. Y., seemed to afford some relief and in December, 1914, he went to Fort Bayard, N. M., in hope of more permanent results. Here the Grim Reaper found him and on Jan. 12, 1915, he bravely surrendered all that young life might hold for him and passed "over the river to rest under the shade of the trees." Able, conscientious, lovable, he left an enduring organization which he builded and scores of friends who will remember him only with love and with regret.

His widow, Isabelle Dalmas Cooke, and three small children survive.

[redacted]

WILLIAM PENN EVANS

William Penn Evans was born in Bridgeport, Penna. He received his technical education in the Polytechnic College, Philadelphia.

His first work was with R. S. Newbold and Son, the Eagle Iron Works, Norristown, Pa. He left the Eagle Iron Works in September, 1873, to accept a position with the Baldwin Locomotive Works in the Drafting Department; he continued in the service of this company, except for a brief interval until his death.

In 1876 he obtained a leave of absence to act as Assistant Superintendent of the Philadelphia and Reading Terminal at the Centennial Exposition. In 1879 he left the Baldwin Locomotive Works to accept the position of Mechanical Engineer of the Missouri, Kansas, and Texas Railroad at Sedalia, Mo. After one year service he returned to the Baldwin Locomotive Works and was appointed Chief Draftsman in 1885, which position he held until 1903. In 1904 he was placed in charge of exhibit of the Baldwin Locomotive Works at the Louisiana Purchase Exposition at St. Louis, Mo., and upon his return to Philadelphia at the termination of the Exposition was appointed General Night Superintendent.

In 1905 he was given charge of the Baldwin Locomotive Co.'s exhibit at the Lewis and Clark Exposition at Portland, Oregon. At the close of the Exposition, Mr. Evans was appointed Northwestern Agent with headquarters at Portland. In 1910 he returned to Philadelphia and became General Inspector which position he held at the time of his death, January 16, 1915.

Mr. Evans was a member of the American Society of Mechanical Engineers, the Engineers' Club of Philadelphia, the Historical Society of Pennsylvania, and the Franklin Institute.

[redacted]

ANNUAL REPORT OF THE BOARD OF GOVERNORS FOR THE FISCAL YEAR 1914

January 12, 1915.

To the Members of the Engineers' Club of Philadelphia:

The Board of Governors herewith presents its report for the year ending December 31, 1914, as follows:

Thirteen stated, two special, and eight joint meetings of the Club were held at which the maximum attendance was 211 and the average 102. Eight regular and one special meeting of the Board of Governors were held.

The Summary of Membership on December 31, 1914, as compared with the Summary of December 31, 1913, is as follows:

	1913			1914		
Class	Resident	Non-Resident	Total	Resident	Non-Resident	Total
Honorary....	1	1	2	2	2	4
Active.......	340	113	453	331	109	440
Associate....	63	10	73	54	14	68
Junior.......	54	11	65	46	10	56
	458	135	593	433	135	568

Twenty Active, four Associate, eleven Junior, and one Honorary Member were elected. Eight Junior Members were transferred to the Active grade, one Junior to the Associate grade, and one Active to the Honorary grade. Four Active Members died. Thirty-six Active, ten Associate, and eleven Junior Members resigned. One Active Member was dropped from the rolls. One Active Member was reinstated to membership.

The record of deaths is:

W. B. Riegner, Active Member, died January 19, 1914.
Charles W. Close, Active Member, died February 7, 1914.
A. E. Harvey, Jr., Active Member, died February .., 1914.
George L. Miller, Active Member, died August 12, 1914.

During the year our special committee on Engineering Co-operation has been actively engaged in the broad movement for bringing about an affiliation of engineering activities in Philadelphia.

The work of the Executive Committee of the Engineering Co-operative Movement is represented by the attached proposed Charter and By-Laws of the Engineers' Society of Philadelphia. The individuals of our Committee are

members of the Executive Committee, and, therefore, have been closely in touch with the preparation of this document. We feel that it outlines a plan which will be beneficial to the engineering profession at large, and also is a plan which should rightly have the support of our membership.

At our Board meeting of December 15, 1914, this plan was presented and unanimously endorsed, and subsequently was presented to our membership at the Club meeting, held December 19, 1914. At the Stated Meeting, the following resolution was unanimously passed by the Engineers' Club of Philadelphia:

Resolved, That the Engineers' Club of Philadelphia endorse the proposed Charter and By-Laws prepared by the Executive Committee of the Engineering Co-operative Movement.

At this writing the following societies are actively engaged in bringing this matter to the attention of their respective governing bodies, with a view to effecting an affiliation in accordance with the proposed Charter and By-Laws of the Engineers' Society of Philadelphia:

American Society of Civil Engineers.
American Society of Mechanical Engineers.
American Institute of Electrical Engineers.
Illuminating Engineering Society.

The other engineering societies represented in Philadelphia are considering means by which they can also join in this movement. It is gratifying to see how enthusiastic this movement is being received by engineers generally, and we confidently anticipate completion of the plan as outlined within the coming year.

The following organizations have been holding meetings in the Club house:

Society of Municipal Engineers.
American Society of Marine Draftsmen, Delaware River Branch.
American Chemical Society, Philadelphia Chapter.
American Institute of Electrical Engineers, Philadelphia Section.
Illuminating Engineering Society.
American Society for Testing Materials.
American Society of Civil Engineers, Philadelphia Association of Members.
American Society of Mechanical Engineers, Philadelphia Chapter.

The following papers were presented during the year:

January 3.—"The Scranton Mine Cave Problem," Eli T. Conner.

January 17.—"Recent Locomotive Development," George R. Henderson.

February 3.—"Mineral Resources of British Columbia and Alberta," Howard W. DuBois.

February 7.—Annual Address, President W. P. Taylor.

February 21.—"Radio-activity with Special Reference to Radium," Arthur W. Goodspeed.

March 7.—"The Rebuilding of Forty Miles of the Lackawanna Main Line," G. J. Ray.

March 21.—"A Hydro-Electric Development on the Tallulah River, Georgia," John Birkinbine.

April 4.—"The Foundations of the Woolworth Building," Edward S. Jarrett. "Difficulties in the Construction of the Woolworth Building," G. F. Shaffer.

April 18.—"Report on Public Service Properties," E. P. Roberts.
May 2.—"Evolution of the Modern Battleship," W. A. Dobson.
May 16.—"Electrometallurgy," Joseph W. Richards.
June 6.—"The Power Problem in the Lehigh District," Hermann V. Schreiber. "An Analysis of Electric Drive in Cement Mills," Thomas H. Arnold.
September 19.—"Modern Road Building Here and Abroad," T. Hugh Boorman.
October 3.—"The Water Supply of Ancient Jerusalem," Henry Leffmann.
October 17.—"Air Conditioning," J. Irvine Lyle.
November 7.—"Physical Photometry," Herbert E. Ives.
November 21.—"Bituminous Coals. Predetermination of Their Clinkering Action by Laboratory Tests," F. C. Hubley.
December 5.—"The Bureau of Standards and Its Relation to the Industries," S. W. Stratton.
December 19.—"Mercury Turbine," William L. R. Emmett.

FINANCIAL REPORT FOR THE YEAR 1914

Statement of Assets and Liabilities as of December 31, 1914

ASSETS

Cash—Colonial Trust Co.—Active Account	$ 609.13	
Colonial Trust Co.—Interest Account	1,526.11	
Petty Cash Fund	200.00	
In Office	68.57	
		$2,403.81
Accounts Receivable		3,610.76
*Building Fund Notes, special fund	3,250.00	
*Second Mortgage Bonds, special fund	200.00	
		3,450.00
*Sinking Fund for Redemption of Second Mortgage Bonds:		
Regular Account	$ 38.50	
Interest Account, special fund	274.10	
Principal Account, special fund	383.16	
		695.76
Inventory of Supplies on Hand		
Wines and Liquors	$267.22	
Restaurant Provisions	124.17	
Cigars	191.29	
House Supplies	28.87	
	611.55	
Fuel	32.75	
		644.30
Insurance		
Perpetual on Club House	$1,603.80	
Employer's Liability	14.58	
		1,618.38

Property

Building No. 1317 Spruce Street	$72,850.00	
Furniture and Fixtures—House	9,417.95	
Furniture and Fixtures—Restaurant	1,421.28	
Library	2,100.00	
		85,789.23
Total Assets		$98,212.24

Liabilities

Accounts Payable		$5,413.23
Bills Payable, Building Account		7,950.00

* In hands of the Trustees for the Redemption Fund of 2d Mortgage Bonds.

Trustees for the Redemption Fund of Second Mortgage Bonds:		
Note, special fund	$3,250.00	
Second Mortgage Bonds, special fund	200.00	
		3,450.00
First Mortgage Payable	40,000.00	
Second Mortgage Bonds	25,250.00	
		65,250.00
Accrued Interest—First Mortgage	1,080.00	
Accrued Interest—Second Mortgage Bonds	1,516.95	
Accrued Interest—Building Fund Notes	312.97	
		2,909.92
Library Fund		6.52
Link Belt Engineering Co. Fund		3.35
Total Liabilities		$84,983.02

Capital (Surplus) Account

Surplus, January 1, 1914		$14,178.68	
Loss for 1914 as per Statement of Income and Expense	$747.07		
Suspense Account, Uncollectable Accounts	202.39		
		949.46	
Surplus as of December 31, 1914			13,229.22
			$98,212.24

STATEMENT OF INCOME AND EXPENSE FOR THE YEAR ENDING DECEMBER 31, 1914

INCOME

Dues—Net	$15,541.07	
Initiation Fees	515.00	
		$16,056.07

Publications

Advertising—Directory	$335.00	
Advertising—Proceedings	571.80	
Sales—Proceedings	57.05	
		963.85

Miscellaneous			
Badge Sales		$9.50	
Interest on Deposits, Active Account	$45.48		
Interest on Sinking Funds	22.88		
		68.36	
Telephone Receipts		150.24	
			288.10
Club House Business			
Billiard and Pool Sales		$197.87	
Cigar Sales		2,297.11	
Lodging		2,897.70	
Rent of Meeting Room		618.79	
Restaurant Sales		7,546.26	
Restaurant Sales, Meals		2,232.00	
Wine Sales		995.89	
			16,166.83
Total Income			$34,033.64

EXPENSES

Salaries and Wages			
Manager		$2,100.00	
House, Salaries and Wages	$2,861.01		
House, Meals of Employees	720.00		
		3,581.01	
Office, Salaries	$1,705.71		
Office Meals of Employees	432.00		
		2,137.71	
Restaurant, Salaries and Wages	2,972.39		
Restaurant, Meals of Employees	1,080.00		
		4,052.39	
			11,871.11
Expense			
House Expense		$1,109.57	
Office Expense		450.49	
Directors' Expense		24.15	
Library Expense		103.85	
			1,688.06
Publications			
Directory Publishing		$ 314.71	
Proceedings Publishing		1,012.71	
			1,327.42
Miscellaneous			
Badge Purchases		$ 9.50	
By-Laws Revision		36.90	
Club Luncheons		400.00	
Entertainment Committee, New Year's Day	$ 3.00		

Entertainment Committee, Reception		192.36		
Entertainment Committee, Smoker		240.54		
			435.90	
Extraordinary Expense, House Account			372.50	
Fuel Purchases		$508.33		
Inventory, January 1, 1914		32.48		
		540.81		
Inventory, December 31, 1914		32.75		
			508.06	
Gas and Electricity			1,138.30	
Insurance Expense			73.44	
Meetings Committee			673.81	
Membership Committee			66.73	
Nominations Committee			2.40	
State Tax on Second Mortgage Bonds			101.00	
Taxes and Water Rent			950.00	
Telephone Expense			414.50	
				5,183.0
Interest				
Interest on First Mortgage			$2,160.00	
Interest on Second Mortgage Bonds			1,230.84	
Interest on Building Fund Notes			397.50	
				3,788.3
Club House Business				
Billiards and Pool Purchases		$ 6.55		
Cigar Purchases		1,851.91		
Wine Purchases		698.26		
			2,556.72	
Restaurant Expenses		797.17		
Restaurant Provision Purchases		7,503.81		
			8,300.98	
Inventory, Dec. 31, 1914				
Cigars	$191.29			
Restaurant Supplies	124.17			
House Supplies	28.87			
Wines and Liquors	267.22			
		611.55		
Inventory, January 1, 1914				
Cigars	$239.32			
Restaurant Provisions	100.15			
House Supplies	62.93			
Wines and Liquors	274.19			
		676.59		
Add Decrease in Inventory			65.04	
Expense of Club House Business				10,922.7
Total Expenses				$34,780.7

Net Loss for 1914.. 747.07

$34,033.64

Respectfully submitted,

J. R. Bailey, *Treasurer*.

Audited and found correct:
Vollum, Fernley, Vollum & Rorer,

Certified Public Accountants.

The following is the report of the Trustees of the Bond Redemption Fund:

Seventh Annual Report of the Trustees of the Bond Redemption Fund
the Engineers' Club of Philadelphia

Being a Statement of Business for the Year 1914

To the President and Board of Governors of the Engineers' Club of Philadelphia:

The Trustees of the Bond Redemption Fund present the following state of business since last report:

Receipts

1914			
January	1, Balance on Hand	$312.26	
	Coupons Cashed	10.00	
February	5, Interest on Note	162.50	
March	5, Share of Surplus	188.12	
December	31, Interest on Deposit	22.88	
			$695.76

Expenditures (*None*)

Balance, January 1, 1915.. $695.76

The Trustees hold bonds Nos. 51 and 52 for $100 each; also note payable by the Club for $3250.

The other funds are on deposit at the Western Saving Fund Society of Philadelphia.

Henry Leffmann,
Edwin F. Smith,
Edgar Marburg,
Trustees.

Respectfully submitted,

THE BOARD OF GOVERNORS,
S. M. Swaab, *President*,
H. L. McMillan, *Secretary*.

SHALL we put your professional card in this space next time?

M. E. HIBBS

Chairman
Publication Committee

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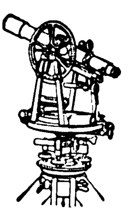

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OF
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OF PHILADELPHIA, PA.

ORGANIZED DECEMBER 17, 1877. INCORPORATED JUNE 9, 1892.

NOTE—The Club as a body, is not responsible for the statements and opinions advanced in its publications.

Vol. ~~XXXII~~ July, 1915 No 3

Paper No. 1150 7

THE ENGINEER AS A CITY HEAD

HENRY HESS

May 1, 1915

We have latterly been hearing more or less of proposals to license the engineer and to regulate him generally. Though the originator of the desire has not as yet been satisfactorily located, his cry found echo in some legislative halls, an echo that was contrary to all engineering law in that it was louder by far than the originating sound. Is the explanation of this paradoxial phenomenon to be found in the spirit of altruistic kindness so prevalent among the followers of Blackstone, who unselfishly consented to follow their country's shout to grace its legislative halls? Recognizing that the unregulated rush to fill up the engineering ranks and knowing full well that overcrowding breeds reduction in emoluments, what could more naturally occur to their collective wisdom than to give the poor engineer a lift out of his pit of unbridled competition by demanding of every hunter in search of a job the production of a duly certified license and so reducing the number of his competitors?

Concurrently there is growing in the community a conviction that much of our country's legislative work would be more effectively done at less cost of effort and with less wasted material resource if the engineer should bring to the legislative grist mill the same regulated logic that his constructive work daily and inexorably demands of him. As the lawyers' work must be fifty per cent. failure, since of two opposing lawyers one must lose, Cokes' disciples are taught a

broadly charitable as well as philosophic view of failure. Not so th engineer; not his a fifty per cent. standard; his employer requir nothing short of a hundred per cent. success. The failure of an im portant machine, bridge or dam is not a mere incident in the eng neer's career, but it is the end of that career. Success, no eighty pe cent. with twenty of failure, but success on success is the stern con dition for the engineer's professional existence.

FIG. 1

When I ran across some biographical notes on the "Engineer the Mayoralty" it occurred to me that this might be basis of a sket of some interest to the members of our little engineering communit soon to expand and embrace all engineers of every affiliation with thirty miles of this hall.

Knowing the onerous burden placed upon the bowing shoulders of our Meetings Committee Chairman in getting papers that could be managed in one short evening, I suggested to him a "short" paper on this subject. Not that I had any real intention of foregoing the privilege of talking to you for as many hours as I could possibly manage before giving you a chance to "get back." Unlike our ex-ball twirling and present evangelistic champion I must leave you that privilege.

FIG. 2

I knew that here had lived occasional engineers in bygone ages who did make for themselves a name, but their engineering was always a secondary issue, as the artist poet Michel Angelo, or that other illustrious military engineer, Benvenuto Cellini, whose engineering was an occasional relief from artistic silversmithing or from highly artistic and decidedly if less praiseworthy, professional storming and

laying low of many fair fortresses belonging to other overlords. But though cities and towns might boast soldiers and even priests as their rulers, they exalted neither engineers nor second cousins of engineers to the dictatorship, nor could I find record of an engineer having with strong hand and overriding will elevated himself into the chair. Still, engineering is a modern profession, so I hoped for better success in my search among our own and our fathers' compeers. Whether my poor bag is the fault of the engineer not aspiring to political leadership or not caring whether the job found him or his legal brother, who more daringly placed himself in the lightning's path, the result is that a paper modestly promised as "short" for once

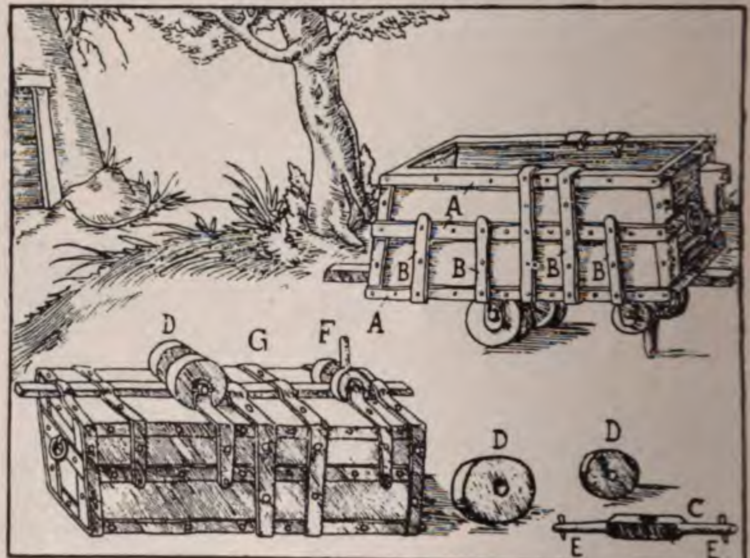

FIG. 3

actually does respond to your silent hope to be soon released to an opportunity to seize and firmly hold a front place at the collation wisely offered by a "House Committee" with a deep insight into the needs of its bimonthly belectured fellow-members.

A contemporary of stiff-necked Gallileo and of the astronomer Kepler, Otto von Guericke lived and died between 1602 and 1686. While Guericke is probably best known for his recognition of the effect of atmospheric pressure, he was the most prominent German engineer of his age. The classic hemispheres of every school treatise

on physics that, when exhausted of air could not be torn apart by twenty-four horses, yet would fall apart on the opening of a small cock to the great wonderment of the assembled notables headed by the Archduke of Mainz, constitute his best known invention. The citizens of his native town of Magdeburg made abundant use of their opportunity to gape at a thirty-six foot high pipe and to question the mysterious antics of a little black devil afloat in the glass top and

Fig. 4

supposed to influence the weather; this water barometer was another of Guericke's contributions to engineering lore based on his investigations of air pressure. Guericke's simple hand operated air pump is the precursor of the vacuum pump of today. His friend, Schott, published the experiments by which Guericke proved that fire could not exist without air. By means of bell signals Guericke demon-

strated the dependence of sound upon the density of the atmosphere. Our well known and popular little man and woman hung on a cat-gut, and retiring or coming out of their retreat, as the weather is foul or fair, acknowledge Guericke's parenthood. In 1661 Guericke presented the manometer to the world. Ten years later saw the construction of the first actual machine operated electric generator consisting of a sulphur ball rotated on an axis and rubbed against the hand. While electrification of a sulphur slab by rubbing was well known, Guericke noted a number of new phenomena, though it remained for later investigators to draw conclusions from them. For the thirty years from 1646 to 1676 Guericke served his native and well beloved city of Madgeburg as its actual and titular chief citizen and Mayor, having earlier, about 1627, served it as alderman. After Tilly's destruction of the city Guericke served the Swedes in Erfurt for seven years, from 1631 to 1638, as chief military engineer. Returning, he justified his townsmen's confidence in him by thirty years' service as Mayor. Guericke's academical career was spent at the universities of Leipzig, Helmstedt and Jena in the study of law. In Leiden he devoted himself to mechanics and mathematics. This was followed by a sojourn in England and France. Then, as now, the German student did not give adherence to any one university, but attended lectures by the most noted specializing expounders of learning at the particular schools to which they were attached, a practice which has undoubted advantages for students more advanced in years than the boys of our colleges.

We must turn back the pages of history for a hundred years to uncover another engineer as Burgomaster of the old Saxon city of Chemnitz, famed to this day for its machine industries. Carl Bauer was thrice called into the mayoralty, having first served his fellow-citizens for a short period in the town council. Then came the Reformation to which he would not conform, and so was relieved of his office in 1552, to die three years later, poor and persecuted as a Papist. Born in 1490, his 28th to 32d year saw him teaching Greek, but so little to his own satisfaction that he took up medicine, chemistry and philosophy at Leipzig, Bologna and Padua, settling down as a physician in 1527 in Joachimsthal from where he was called to Chemnitz as city physician or, as we would call him today, Director of the Bureau of Health. After the fashion of those days he had to have a high and mighty protector, whom he found in the person of Duke Moritz of Saxony, who appointed him also his house

historian with free lodging and a yearly stipend. As an author Bauer is well known as Georgius Agricola. The world is indebted to him for a history of German Mining and Metallurgy in twelve large volumes and with 292 copper plates. It is clear that no one not himself an engineer could have so correctly and analytically described engineering methods and machinery. Agricola, or Bauer, published this work in Latin under the title "De Re Metallica Libre XII." In his introduction he gives the interesting content:

"The first book is a recital of what may be said against mining and metallurgy and against the operation of mines and furnaces and what may be said in their favor.

"The second teaches the miner and in dialogue form deals with the finding of ore bodies.

"The third deals with ore bodies and veins and their working.

"The fourth deals with the survey of the ore bodies and the duties of the miner.

"The fifth teaches the digging of ores and the art of recognizing them.

"The sixth is descriptive of mining tools and machines.

"The seventh deals with the testing of ores.

"The eighth teaches how to roast, stamp and wash ores.

"The ninth explains the science of ore separation by smelting.

"The tenth introduces the student of metallurgy to the art of separating silver from gold and of lead from silver.

"The eleventh shows how silver is separated from copper.

"The twelfth gives directions for the preparation of salt, of alum, of iron vitriol, of sulphur, of bitumen and of glass."

A few illustrations from this truly monumental engineering history may not be without interest.

Figure 1 carries the descriptive caption: "A the water-wheel, B the wheel spindle, C the stamp mill, D the round stamper, his hole E that goes through the middle, the lower millstone F, and his round basin G, his hole (spout) H, his milling iron (driver) K, the beam L, the iron pinion M, and the tooth wheel N of the spindle B. The vats O, the support boards P, the spindles Q, the stirrers S, the back gears T. V a spindle locked to the drive and its toothed wheels X. Three stamping troughs Y, their wheels Z with straight arms AA and cross arms BB."

This very clear perspective drawing can serve as a model to modern draughtsmen. The device of showing concealed parts and shapes

separately in the foreground is neat and admirably clear. In times when mechanics were all-round men, a drawing of this kind was really better than our modern plans, elevations and cross sections. A perspective like this gives an immediate and comprehensive understanding. The next illustration (Fig. 2) gives a larger view of the stamp mill in the background of the first view.

Agricola supplements these two views of the mill with one showing workmen fashioning various parts of the mill and another showing details of the lorries or "dogs."

The description that our friend, the engineering Burgomaster Bauer, with the nom de plume Agricola, gives is so interesting that I cannot forego a few sentences, though they lose much of their quaintness in the translation from monkish Latin, by way of old German into modern English: "How the ground-up meal always falls into the first barrel, therefore also the water, which again from that runs into the second, which is lower, and from that other into the third, which is very low, and from the third very often into the very clear trough hollowed out of a tree. But in every barrel there is placed quick silver.———— So the three quirls (stirrers) in each barrel drive about the meal mixed with water and separate the little grains of gold, which in falling down are eaten up by the quicksilver and cleaned, but the unclean is taken away by the water. But the quicksilver is poured into a soft hide or cotton sheet, which is squeezed and so the quicksilver flows through that into a pot underneath, but the gold prettily stays in it."

Then Agricola describes the trough method as an alternative, but considers the first superior. He then tells that the lumps that contain zinc are not to be despised, and how the zinc may be recovered.

Agricola explains at length and with much quaint detail the origin of the term "dog" for the ore lorries and finds the explanation in the howlings that accompany its progress.

I am indebted to "Prometheus" for this history of our two engineers who so worthily and enduringly wore the mayoralty mantle and chain. Not for a moment did I dream that their example would not fire other members of our profession to strive after and as tenaciously hold onto similar honors. At first my search for their names and doings was carried on in ease and at dignified leisure, to break into a mad scramble toward the end aided by several librarians. The German records particularly were fruitful in disclosing many engineers in city and governmental employ (aside from the military

branches) where they reaped honors and public recognition, though rarely much filthy lucre; but as heads of their municipalities these two lone examples remained in their stately isolation. While the engineer has for a long time been recognized as a valued and trusted employe of civic government, it is only within a very few years that our own States and Towns are grudgingly beginning to serve their own best interests by turning to the engineer, and then under conditions that only men having the strongest sense of duty to their communities will endure.

DISCUSSION

Mr. Ledoux: It seems from the illustration that it represents the old-fashioned old Cornish stamp head. Was this form invented before Guericke's time?

Mr. Hess. That was not Guericke, that was Bauer, evidently an historian, he described it so intimately and completely in detail that he must have been somewhat of an engineer himself. Bauer or Agricola did not describe that as anything particularly new.

Mr. Ledoux: Mechanical mining was probably in use to a very large extent many centuries before that. Perhaps Dr. Chance would say something to add to the discussion.

Dr. H. M. Chance: I did not hear all that Mr. Hess said in regard to Agricola's work on mining which has been illustrated on the screen by the reproduction of cuts showing stamp mills. Agricola was quite a prolific writer. He wrote a number of important scientific essays apart from this work. He evidently was not only a student but a practical miner, something of a geologist, and a close student of nature. It is only within the last year that his great work has been available in English. It may be of interest to members of the Club to know that this work has been translated and published about a year ago by Mr. H. C. Hoover, a noted and celebrated mining engineer, who has done wonderful work in relieving distress among refugees from the scene of the present European war. Mr. Hoover is an American, but resides a greater part of his time in London. This work of Agricola's was translated by Mr. and Mrs. Hoover. I understand they spent five years in study and research, including the different copies, prints and reprints of this work that could be found in the libraries in Europe. The translation reproduces all of the original illustrations in fac-simile. The book is a large volume, handsomely bound in vellum, and reproduces the style of one of the early editions almost in fac-simile. The same general style of type has been used. The work had previously been translated into German, Spanish and French, the original having been written in Latin. I think there were two German translations—one in the sixteenth century and the next about a hundred years later. They are both rare. The American Philosophical Society has a copy of one of these editions. It was translated into Span-

ish, and I think into French, but no one seemed to have sufficient interest to translate it into English until Mr. Hoover and his wife published their translation last year. Those who wish to obtain a copy of the book can do so by writing to the "Mining and Scientific Press," a San Francisco publication, with representatives in New York. It is sold at a price less than the cost of publication. Mr. Hoover's desire was to place the work within the reach of everyone. It should be in every engineering library. Aside from the special interest to mining engineers and metallurgists, describing accurately the methods in use at that time—I think it was in 1530—there is a surprising wealth of detail interesting to engineers in other branches of engineering. I recall a full page illustration which shows every detail of an ordinary blacksmith's bellows, every piece of wood, every screw, every iron strap, and even the shape of the leather that must be cut for the valves, a bellows such as you can see in use today, and it is interesting to see how in some respects we have made but little advance over the methods used four hundred years ago.

Mr. Hess has paid a sufficient tribute to this writer, but I would like to say that he was a very thorough, painstaking observer, and is recognized as one of the fathers of mining literature.

Mr. Nichols: Dr. Chance mentioned the bellows. I wish someone would tell me whether there is anything being done now with the old-fashioned English bellows; there is not a blacksmith shop that I know of using them, and I was wondering if they had gone out of existence.

Dr. Chance: Oh yes, they are used; nearly every English household has a small pair of bellows after the same pattern as the English blacksmith bellows, and these they use for their fires.

Chairman: A question occurs to me in connection with the mercury process. Is that now used in substantially the same form as described?

Dr. Chance: That is the method in ordinary use for separating the amalgam; it is then retorted to drive off the mercury; all those methods are still in use. Any tightly woven cloth can be used, the mercury being squeezed through it.

It may be of interest as showing the appreciation by engineers of the value of Agricola's work, and of the service rendered by Mr. and Mrs. Hoover in translating it into English, to mention the fact that the Mining and Metallurgical Society of America last year awarded its gold medal to Mr. and Mrs. Hoover in recognition of this service. I regret that Mr. Hess did not let us see more of the illustrations, because many of them are of great interest, especially those showing the methods of raising water, elevators, water wheels, horsepowers, etc.

Paper No. 1151

ELECTRIC WELDING

J. H. BRYAN

May 15, 1915

The art of welding, which may be broadly defined as the joining together of metals into intimate and permanent union, dates back to the early days of history. Until within the last half century, the only practicable method of making a weld was by a process with which we are all familiar, namely, that of heating the pieces to be joined at the point where the union was to be made, then, when they were almost at fusing point, placing them in their proper relation and completing the weld by hammering. This is a comparatively simple operation, and one which is carried out daily in every cross roads blacksmith's shop. There are, however, limitations to the scope of this class of work, and until the introduction of other methods, some of which we are going to consider this evening, these limitations were insurmountable, both from the standpoint of practicability and of cost. The introduction of the electric arc welding process and the kindred ones of incandescent electric welding, possibly better known as butt and spot welding, and also of the gas welding processes has, however, very greatly increased the field of possibilities, and we are now able to produce results which it was theretofore impossible to obtain.

Before going further, it might be well to outline some broad definitions of the different processes of welding. These processes may be first divided into two, the first known as Autogenous welding and the second welding by pressure or hammering. The first of these terms, Autogenous welding, may be defined as the fusing together of two metals without pressure by causing them to melt, then unite as they cool. Welding by the use of the electric arc or by the various processes employing gases, such as the oxy-acetylene or oxy-hydrogen method, come under the heading of Autogenous welding.

The blacksmith's weld is one form in which hammering is used to obtain a union of the pieces to be joined. Incandescent welding is another application of the same principle. In this method, as it is most commonly used, the two parts to be joined are placed in contact with each other and by means of suitable equipment a heavy current is caused to pass from one piece to the other. The value of this current is such that it heats the metals to the fusing point, when the two parts are pressed together and the weld thus completed.

A recent modification of incandescent welding is that known as electro percussive welding. It differs from the better known pro-

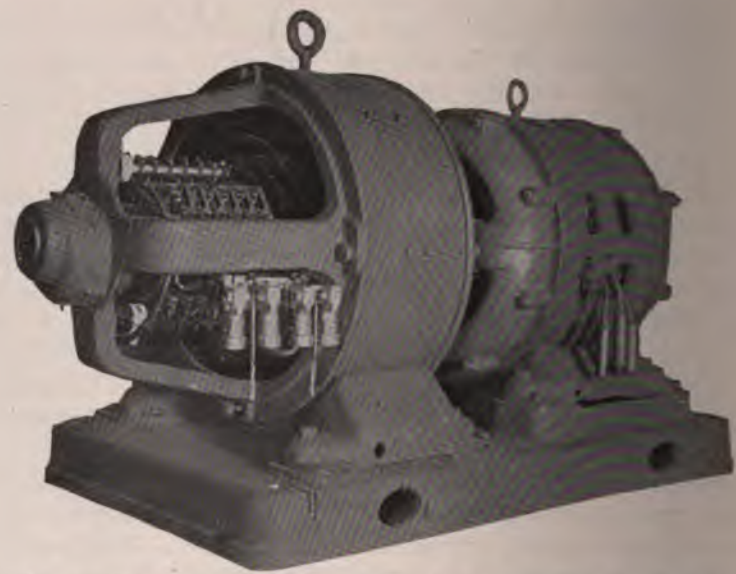

Fig. 1.—500 amp. arc welding motor generator with AC motor.

cesses in that it is practically instantaneous, this property enabling us to weld metals having widely differing melting points or metals which are not commonly susceptible of being welded. Although this process is of a very recent origin, it has proved very valuable.

Electric Arc Welding

Referring again to electric arc welding or, more briefly, arc welding, as a commercial process, this may in turn be divided into two general classes as follows:

First, Benardos or carbon electrode process in which the arc is drawn between the metal to be welded and a metal electrode.

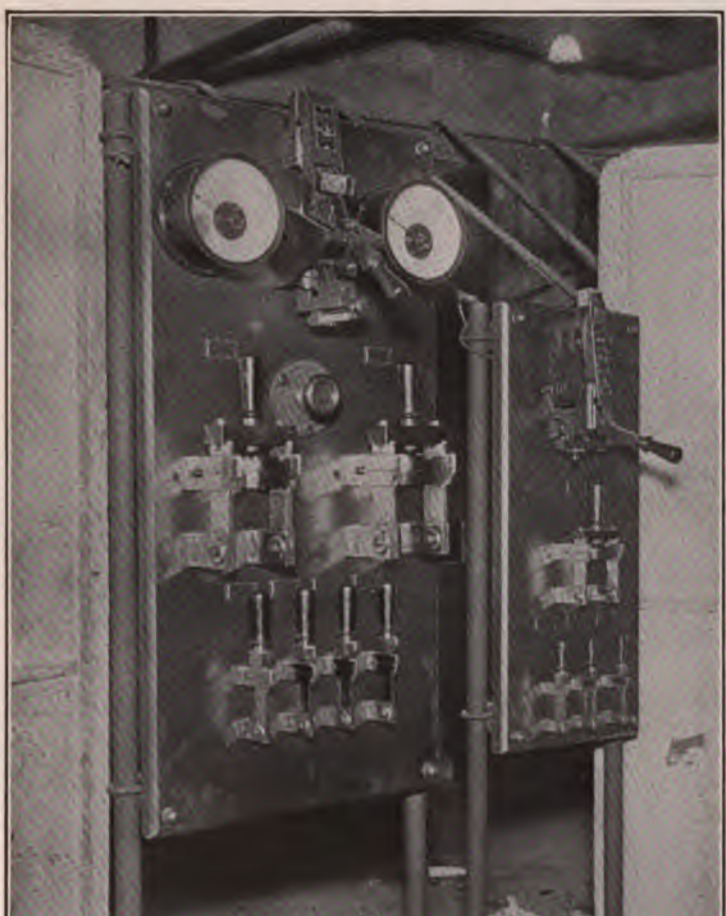

Fig. 2.—Front view of arc welding control panel; on left panel for control of 500 amp. generator and welding circuit. On right panel outlet for metal electrode welding.

Second, Slavianoff or metal electrode process in which the arc is drawn between the metal to be welded and a metal electrode.

These two processes are generally referred to as carbon or graphite electrode and metal electrode welding, respectively.

In addition to these there is the Zerener process, in which the arc is drawn between two carbon electrodes, as in an arc lamp, and the metal to be welded is placed in contact with the arc. This is, however, not considered as a commercial proposition, in this country at least, as its field of application is limited, and the apparatus itself is unwieldly.

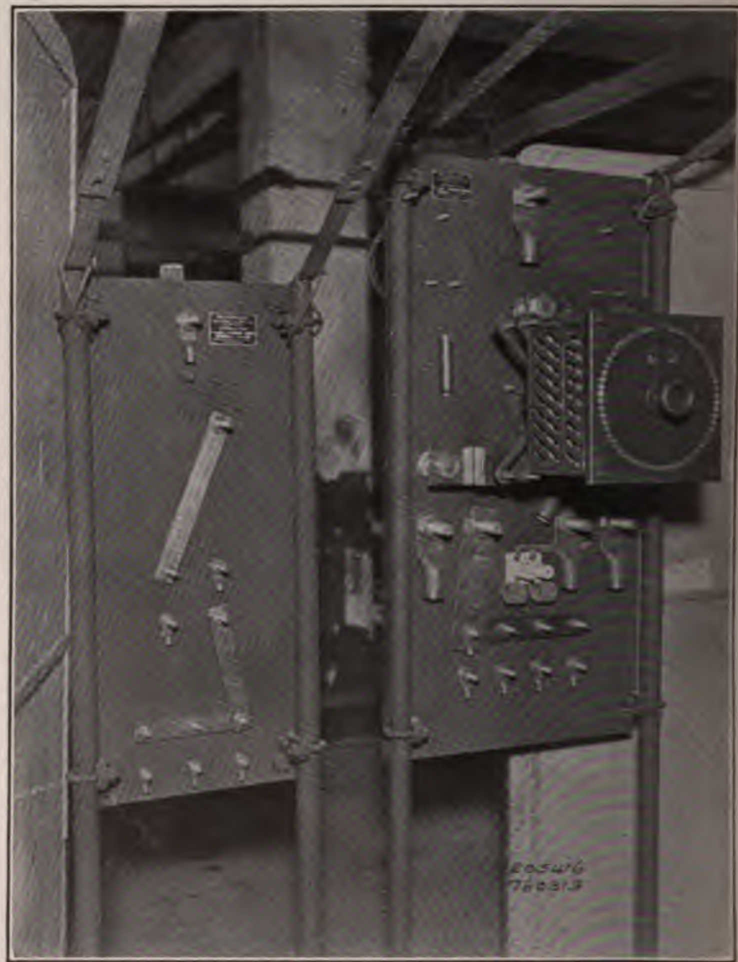

Fig. 3.—Rear view of control panel illustrated in No. 2.

Carbon Electrode Process

"In carbon electrode welding, the metal to be welded is made one terminal of a direct current circuit, the other terminal being a carbon electrode. Upon closing the circuit by bringing the carbon electrode into contact with the metal and then withdrawing it to a distance, an arc is drawn between the two terminals. Through the medium of the arc, which is the hottest flame known, (having a temperature between 3500 degrees and 4000 degrees Centigrade—

Fig. 4.—300 amp. portable arc welding equipment arranged to supply two operators. (With D. C. Motor.)

6300 degrees to 7200 degrees Fahrenheit) the metal may be either entirely melted away, moulded into a different shape or fused to another piece of metal as desired.

"In the first attempts to weld by this process the carbon electrode was made the positive side of the circuit and the metal to be welded the negative. Practice, however, shows that it is better to reverse these conditions, for if not, since the flow of current is from positive to negative, particles of carbon will find their way into the welds, thus tending to make them exceedingly hard and consequently diffi-

cult to machine. A further very important advantage is gained by making the metal to be welded the positive terminal. It is a well known fact that in a direct current arc the highest energy consumption—about 75 per cent. of the total—and therefore the highest temperature, occurs at the positive terminal, and, while no very extended data are available regarding the behavior of arcs having either or both electrodes of metal, there is considerable information regarding carbon arcs and it is fair to assume that, with reference to this par-

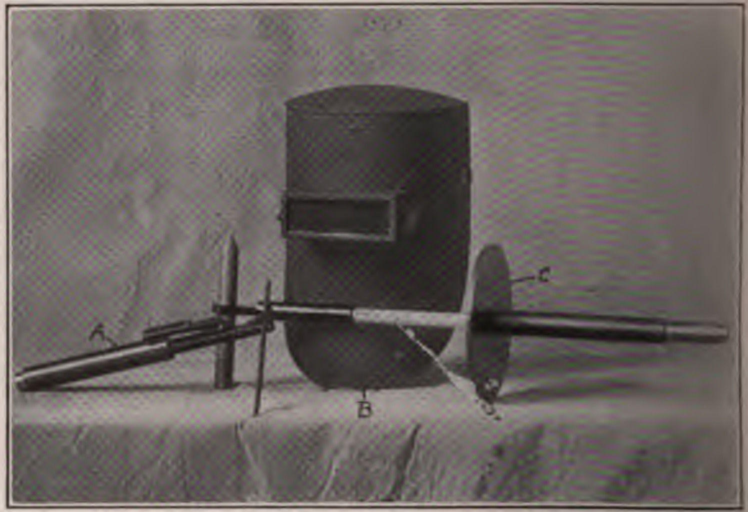

Fig. 5.—Accessories used in arc welding. (a) metal electrode holder. (b) mask. (c) carbon electrode holder.

ticular point, there is not a wide difference between them. Since the positive is at the highest temperature, the greatest amount of heat is at the point to be welded and therefore where most needed." (C. B. Auel, American Machinist 1911.)

Metal Electrode Process

The metal electrode process of welding is a somewhat later development than the carbon electrode method and, as has already been indicated, it differs from the latter in that a metallic electrode is substituted for the carbon.

APPARATUS REQUIRED

The essential requirements for arc welding are:—

1st. A suitable source of direct current supply.

2nd. A steadying resistance to be placed in series with the arc, together with means for adjusting same, i. e., suitable control equipment.

3rd. A means of holding the electrode so that it may be properly manipulated by the operator.

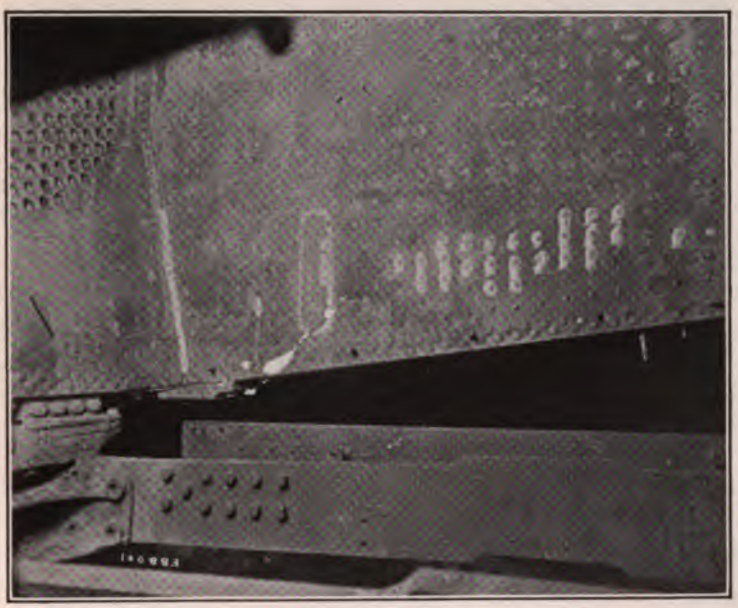

Fig. 6.—View of locomotive fire-box repaired by electric arc welding.

4th. Protective covering for the operator.

5th. Suitable filling material.

6th. Miscellaneous material such as flux, fire-clay or carbon blocks for making molds, etc.

DIRECT CURRENT SUPPLY

Taking up this equipment in order, the direct current supply can be obtained in any one of several different ways. If direct current

is available from a shop or commercial circuit, welding can be done directly from this source of supply, but this method has been found to be very wasteful of power and should not be resorted to except where welding is to be done only at very infrequent intervals. An additional disadvantage of the use of the shop circuit as a source lies in the fact that, unless arrangements are made for insulating the work from ground, the shop circuit is grounded, with attendant danger to other employees in the shop, as well as to the welding operators. A much more economical method is that of using a motor

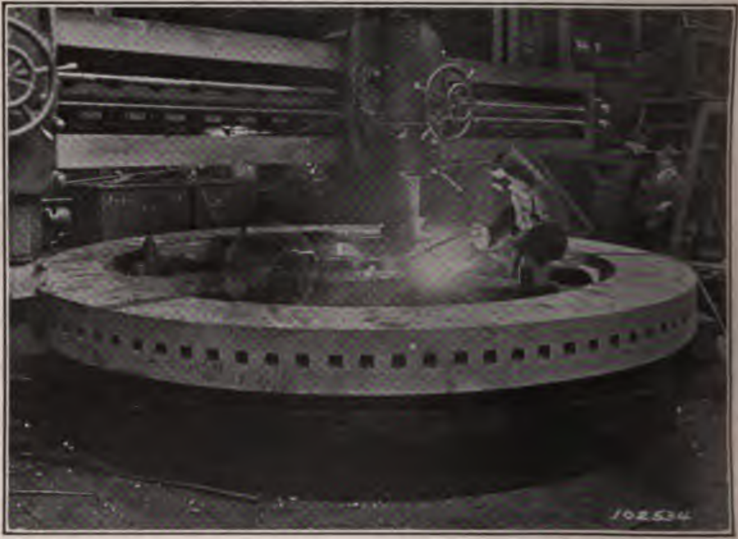

Fig. 7.—Repairing steel casting by electric arc welding, without removing casting from machine tool.

generator set, the motor being constructed with characteristics suitable for operation from the shop or other circuit, and used to drive a low voltage generator. In case electric power is not available, the generator may, of course, be driven by belts from a steam or gas engine or from a line shaft.

The generator may be either shunt or compound wound, the shunt wound machine being satisfactory where only one arc is to be operated, while the compound wound machine is preferable if several arcs are to be supplied from the same unit. Experience has shown that generators giving a potential of 75 volts or thereabouts will enable satisfactory results to be produced.

Control Apparatus

As different welds require different strengths of current, it is at once evident that there must be some means of regulating the current supply. This is usually effected by inserting resistance in the welding circuit connecting it in series with the arc. Without this resistance, a condition of practical short circuit would occur at the moment the electrode was touched to the work when striking the arc, and, even after the arc is drawn and normal operation begun, the series resistance is necessary for the purpose of steadying the arc, much as is the case in the ordinary arc lamp.

Fig. 8.—Steel header with tubes welded in by the electric arc processes.

Electrode Holders

Suitable electrode holders must be provided both for carbon electrode and for metal electrode welding. There are a number of forms of these in use at the present time, all of which are arranged with either a spring or a positive clamp for holding the electrode, the construction of the holder being such that the electrode may be renewed in a minimum of time. The metal electrode holder differs from that for the carbon electrode in that it is lighter and more compact. The carbon electrode holder has a disc shield on the handle to protect the hand of the operator from the heat of the arc, which, when heavy currents are used, would cause discomfort. This shield is not necessary for metal electrode work, as the gloves of the operator constitute an ample protection.

Protective equipment is necessary for the operator on account of the fact that exposure to the rays of the arc causes an irritation and subsequent peeling of the skin if the exposure has been sufficiently

long, say, several minutes. The irritation is very similar to sunburn and is uncomfortable, but no serious consequences ensue and at the end of a few days all traces of the burn disappear. The clothing has been found to be ample for the protection of the body. For the eyes and face of the operator a hood or shield is provided, both of these being arranged with windows of thick colored glass, through which the welding is observed. The hands and wrists of the operator should be shielded by gauntleted gloves, which are preferably of leather, although canvas gloves have been found satisfactory. The window of

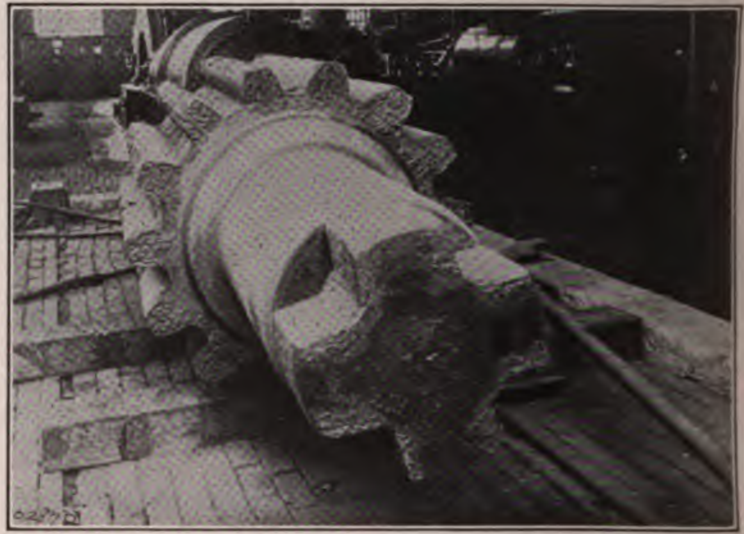

Fig. 9.—Steel blooming mill pinion with worm coupling end repaired by the electric arc welding. (Courtesy American Rolling Mills.)

the hood or shield should be provided with several pieces of glass in layers, one or more of ruby glass, and one or more of blue or green, the combination of these colors being much more satisfactory than any one of them used alone. There are a number of special welding glasses on the market at the present time, most of which will prove satisfactory.

In addition to the protective covering for the operator himself, arrangements should be made for a suitable enclosure around work and operator so that the intense brilliancy of the arc will not interfere with other workmen in the vicinity.

Filling Material

When the carbon electrode is used, the filling material is usually of the same metal as that being worked upon and may be used in any convenient form. For instance, when welding steel and iron, filling material may be in the form of rods, clippings from boiler plate, steel clippings, etc. For cast and malleable iron, soft iron rods, punched iron scrap or special cast iron filler may be used.

These filling materials are fed into the welds and fused into place much as solder is applied with a blow-torch.

When metal electrodes are used for welding iron and steel they

Fig. 10.—Worn armature shaft taper and keyway repaired by electric arc welding. On left, shaft as received; center, shaft after welding was done; on right, shaft after having been machined and having new keyway cut. (Courtesy Electric Rwy. Journal.)

should be of the best quality of soft iron or steel wire and may range in diameter from ⅛ inch or less up to ¼ inch. The length most generally used is about 12 inches. Copper, bronzes and brasses with a low percentage of zinc may also be welded by this process, in which case the electrodes should be of the same material as that being welded. Where the zinc content of brasses is high, it volatilizes to such an extent as to make the work porous and brittle.

Procedure

In making a weld by the carbon electrode process, the work is connected to one terminal of the machine, usually the positive, the electrode holder being connected to the opposite terminal. The work

if small, may be laid upon a metallic table which forms the positive terminal. The resistance of the circuit having been adjusted to what is considered the proper value for the work in hand and the circuit breaker and main switch being closed, the operator assumes his position in front of the piece to be welded, taking the electrode holder in one hand and having flux (if same is used) and filling material within easy reach. He finally closes the window of the hood, touches the carbon electrode to the metal to be welded and instantly withdraws it to a distance of 2 inches or more, thus striking the arc.

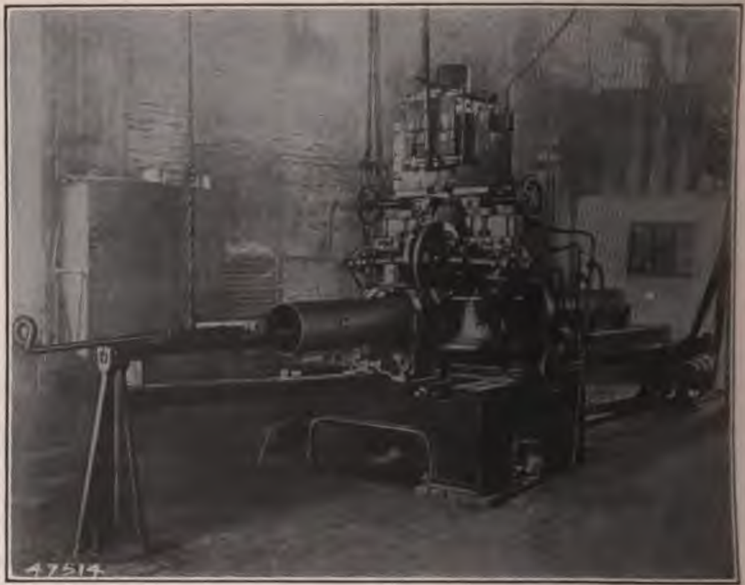

Fig. 11.—Manufacturing large pipe by continuous butt welding machine.

Experience has indicated that with a long arc there is less opportunity for carbon particles to enter the metal and in this way produce a hard weld; the heating effect is also more regular and more evenly distributed. For these reasons the arc should be as long as possible, about 3 inches to 4 inches being the usual length. If the arc is found to be too fierce or to go out due to insufficient current, the resistance in circuit may be increased or decreased accordingly.

After the arc is drawn it is allowed to play upon the work, being given a rotary motion by the hand. The object of this motion is to

heat a comparatively large area of the surface about the weld so that the consequent cooling will take place more slowly and there will be less danger of cracking the work or of making a hard weld. When the metal flows, the flux (if used) and the filling material should be added a little at a time, the arc, of course, being continued until the metal is thoroughly melted and the weld made. As soon as the metal commences to cool it should be hammered thoroughly in order to

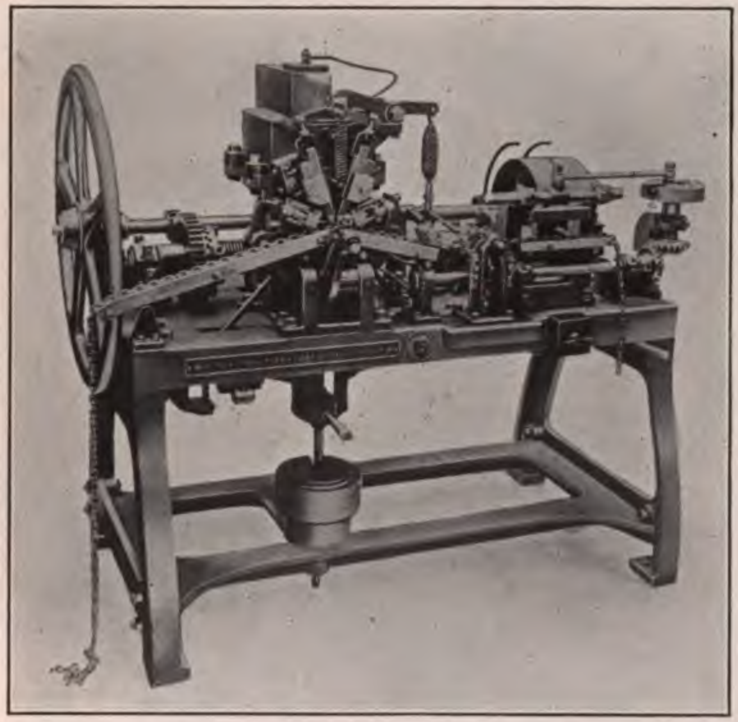

Fig. 12.—Automatic butt welding machine for manufacturing chains.

prevent sponginess and to give the metal a finer grain. All oxide and other impurities must be kept out of the weld. It is advisable, therefore, to make, if possible, one continuous application of the arc. When, however, more than a single application is necessary, care should be taken to remove all the scale. This may readily in most cases by means of a stiff wire brush. Similarly should be cleaned before commencing the weld. To accor

chipping may be resorted to or the piece may be tilted, the arc applied and the impurities allowed to run off by gravity as fast as melted.

The current required for carbon electrode welding varies from a minimum of about 200 amperes to a maximum of around 700 amps. or even more in very heavy work. In general, however, 300 to 400 amperes has been found to be sufficient for ordinary carbon electrode work.

Fig. 13.—Machine for welding fish plates to rails.

As is indicated in the foregoing, carbon electrode welding is more or less of a puddling process. A considerable amount of heat is generated and this is, in many cases, objectionable on account of the expansion of the work, in which strains may be set up on subsequent cooling and shrinking. In work where trouble of this nature is liable

to be experienced, pre-heating may often be used to advantage. On small work this may be done by the use of the carbon electrode. The arc is drawn just as in welding, but it is moved about over the piece without being held in any one place long enough to cause fusion.

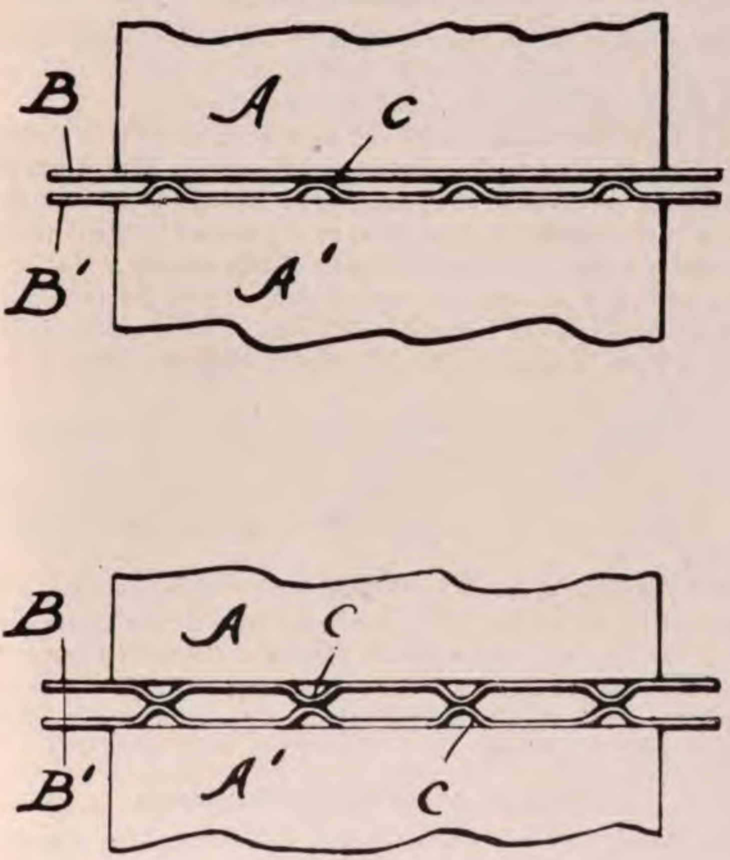

Fig. 14.—Diagram illustrating point welding. A, A-1—Jaws of spot welder. B, B-1—Pieces of metal to be welded. C—Points raised by indenting. Welds take place at point C.

With larger pieces, a temporary furnace may be made by laying fire brick together loosely to form an enclosure around the work and over it. Heating may be done in any convenient manner either by the use of oil, gas or coal. When the work has reached a red heat, the

cover is removed and the welding done without taking the piece from the furnace. After the welding has been completed, the cover is replaced and the work allowed to cool slowly, either with or without a second application of heat.

Metal Electrode Process

The metal electrode process, though a considerably later development than the carbon electrode method, has a field of application very distinct in many cases from the other process.

A principal advantage of its use is in work where it is desirable to localize the heat to the greatest extent possible, thus minimizing strains due to expansion and subsequent contraction. An example of this is in the welding of sheet metal or of a broken bridge in the flue sheet of a boiler. Another advantage of this process is that it enables welding to be done in a vertical plane or even from the underside of the piece to be repaired. This class of work is done daily in railroad shops in repairs to the side sheets and crown sheets of locomotive fire-boxes.

The method of using the metal electrode differs from that with the carbon electrode in the fact that a much shorter arc, generally ⅛ inch to ¼ inch in length, is used and also in that the electrode forms the filling material as it melts and flows into the fused portion of the work.

With the metal electrode much lower currents are used than in the carbon electrode process. The maximum value hardly ever exceeds 150 to 175 amperes. For a greater portion of the work a current of about 90 to 130 amperes is found satisfactory, although the amount of current required will vary with the size of the electrode and the class of work being done.

Cutting by use of Carbon Electrodes

The carbon electrode process is also well adapted for cutting of metals. In cutting the arc is drawn just as in welding and is played along the line to be cut, provision being made for the melted metal to run off. Very rapid work of this sort can be done, especially if heavy currents are used.

This process of cutting is used to advantage in work such as cutting off risers and sink heads from castings in a steel foundry, cutting up scrap, and the like, where rapidity and cheapness are of more importance than absolutely smooth finish and accurate work.

Application

In spite of the fact that arc welding as a commercial process is of comparatively recent origin, it has been found to have a considerable and ever widening field of applicability. It has shown itself to have a distinct range of usefulness, in which it is unsurpassed either by blacksmith welding or by any of the systems of gas welding.

In the repair work of steam railroad shops arc welding equipment has shown itself to be an exceedingly valuable adjunct. Among the principal uses of arc welding equipment in steam railroad shops are the following:—

Flue welding,
Fire-box repairs,
Frame repairs,
Building up of worn parts.

Besides these there are innumerable minor uses for the equipment.

Flue welding is being done by practically every large railroad shop in the country at the present time and this welding is, almost without exception, being done by the electric arc process using the metal electrodes. The advantages of welded flues lie in the fact that the results obtained are practically permanent since the flue and sheet are bonded together without a joint. A welded flue in which scale or other troubles did not develop, could remain in place indefinitely were it not for the federal limitation of three years. The elimination of leaky flues means not only that road failures due to this cause will be entirely eliminated with attendant delays and expense, but also that maintenance expense on this account is reduced to a minimum. In this connection, I would like to quote from the proceedings of the International Railway General Foremen's Association, 1914, the quotation in question being a part of the report of the committee on autogenous welding and covering the experience of one road (C. of Ga.):—

"We have in service today over ninety locomotives with flues welded to back flue sheets, making a total of about 27,000 flues. Out of this number of locomotives in service with the flues welded, we have our first engine to fail on line of road with flues."

It is interesting to note that the flue sheet is found to be in better condition upon removal of flues than is the case where flues have not been previously welded in. This is due to the fact that the welding builds up the sheet around the flue holes to about to original thic

ness. Where welded flues are to be removed it only rquires a few hours longer to cut down the beads and by the use of a special tool for facing off the rough surface after the flues are removed, a good, clean sheet is left.

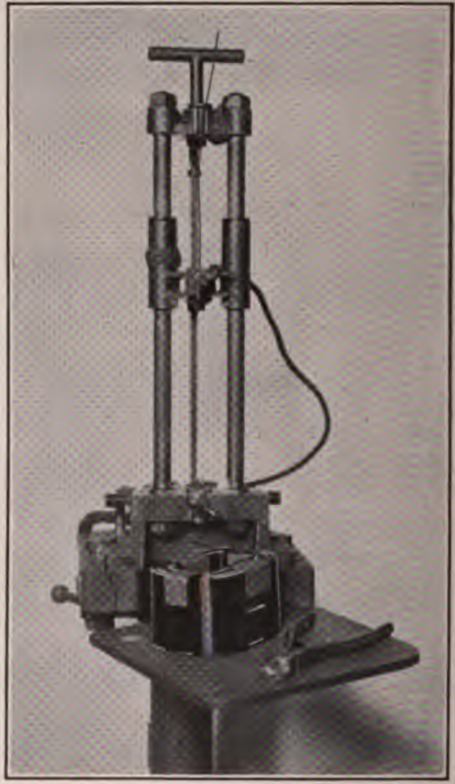

Fig. 15.—Electro percussive welding. Machine welding leading in wire on field coil.

Flue welding has not been entirely satisfactory in every case, but it is believed that the difficulties which have been experienced have been due to methods used and not to the process itself, and these difficulties seem to be diminishing with the increasing experience which is being obtained on this class of work.

Fire-Box Repairs

Closely related to flue welding is the subject of fire-box repairs. The defects to be repaired include cracks in the side, flue, door and crown sheets, leaky stay-bolts, leaky seams, etc. Also sheets will often be found to be in such condition that repairs are impossible and it is necessary to put in patches. All of this class of work can be done very satisfactorily by the use of the arc welding equipment. In the case of cracks, etc., it is necessary that the sheet be cut along the crack into a notch or "V" shape so as to enable the weld to extend through the whole thickness of the sheet. The "V" is cut either by the use of the carbon electrode, or preferably by a chisel. It is then filled in, using the metal electrode and a slight reinforcement built over the outside of the weld.

Where a sheet has gotten into such shape that it is necessary to replace it, it may be cut out by the use of the carbon electrode and a new section welded in. Half side sheets, door sheets, etc., are being welded in without difficulty.

Broken locomotive frames are very satisfactorily repaired by the use of the electric arc. The frame is prepared by notching either from one side or from both sides, preferably the latter; the notch is then filled in by the use of the metal electrode. A reinforcement is also built up around the frame at the place where the weld is made, so as to give extra strength at this point. A great advantage of the use of this process here lies in the expedition with which the work may be completed, as no dismantling of the locomotive is necessary beyond that required to allow the welder to secure access to the broken parts. Cases have been known where a frame has been welded without drawing the fire.

Savings Effected by Arc Welding in Railroad Shops

The following figures were taken from records of actual repairs made in a large railroad shop in the middle west at various times, the figures given being a comparison between the actual cost of welding and that of putting the apparatus back into service by methods previously used, either by replacement or by repair of the old parts. The arc welding costs were based on a power cost of 51 cents per hour for the carbon electrode and 17 cents per hour for the ı
trode, together with cost of labor and overhead charg
cent.

	Cost of Welding	Cost by other Methods
Plugging 51 holes in expansion plate, holes 1″ dia. by ½″ deep	$2.75	$10.15
Repairing mud ring	6.50	34.57
Cutting four 6″ holes in tender deck sheet ½″ thick	1.08	8.35
Welding eccentric strap, broken through neck	1.08	41.28
Welding two spokes in driving wheel center	7.98	99.98
Welding cracks in side sheets	26.15	31.79
Repairing fire-box	134.89	869.58
Building up flat spots on locomotive driver	.40	225.00

Numerous other figures could be presented showing similar savings.

With reference to the last item given above, namely, that of building up flat spots on locomotive drivers, the repair in this case is effected by welding at the roundhouse without withdrawing the locomotive from service. The tire is simply built up at the flat spot and filed to shape, using a templet. Against this the cost of repair by other methods would include the sending of the locomotive to the shop and having the entire set of drivers turned down, which usually means putting the locomotive out of service for at least a week or ten days, as well as the loss of at least one year's wear on the tires. Taking into consideration the loss of revenue from the idle engine, the cost of the older method might easily be $500 or more.

The statement was recently made by a motive power official of one of our large railway systems, in the course of a paper on the subject of arc welding, that in one shop of this system, savings amounted to $1200 per month were being effected by an equipment of 500 amperes capacity, and this is not an exceptional case.

Electric Railways

Electric railways have found an instrument of great value in electric arc welding. In addition to the use of this process in their shops for repairs to their rolling equipment, they are using arc welding for a wide variety of track work, such as rail bonding, frog and switch repairs, low joints, etc.

The shop repairs made by electric railways range from the filling of a worn dowel hole in a bearing cap to the reconstruction of a railway motor. Sheet metal gear cases which have holes worn in them are easily repaired by placing a new sheet over the hole and welding around the edges. Dowel holes which are worn may be filled

with solid metal and then drilled and reamed to the proper size. Armature shafts with worn keyways or worn tapers are built up and re-machined to proper size. Parts of trucks which have been worn by long service can be brought back to original dimensions. In fact, the electric railway shop offers almost as wide a range of applicability for this process as does that of the steam railroad.

A number of electric roads all over the country are using the arc welding process as a means of making track repairs and also in new construction and rebuilding of lines. Welding of rail joints is being extensively done. The method of making a joint by this process consists of using a strap or plate which is put across the joint just as is the ordinary splice-bar, except that the joint is not made up com-

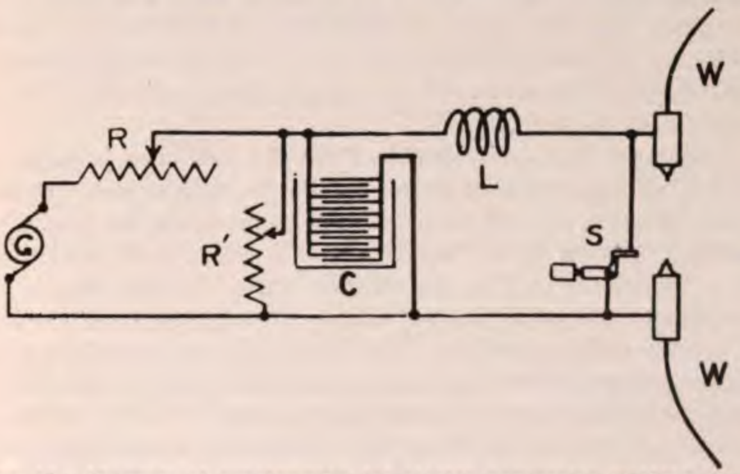

Fig. 16.—Diagram of construction for electro percussive welding. G—Generator; R, R-1—Resistors; C—Condenser; L—Inductance; S—Short circuiting switch; W, W—Jaws holding wires to be welded.

plete by bolting as is the case with the other methods. The plate may be clamped to place or may be held by one bolt through the end of each rail. The welding is done by the use of the metal electrode which is applied at the top and bottom edges and the ends of the plates. The advantages of this method of making joints lie in the fact that a permanent joint is secured, that no additional bonding is required, and last, but not least, that the cost of making up complete by this method is considerably less than by other of making welded joints.

A source of considerable expense on roads where traffic is heavy lies in cross-overs and frogs. These wear rapidly under the pounding of traffic and will need frequent repair or renewal. These repairs can be made speedily and cheaply by the use of the arc and the results obtained will be almost as permanent as is the case with the original material.

Welding From 600 Volts

A large number of electric railways are at the present time doing welding from the trolley circuit, using resistance in series with the arc to hold the current at the required value. Satisfactory work can be done by this method, but it has two very important disadvantages; one of these being it is extremely wasteful of power, and the other, that the danger to the welding operator is very considerable, on account of the fact that one side of the welding circuit is grounded and the operator is in constant danger of serious or fatal injury from shock.

Taking the first of these objections, the difference in power required can be easily seen by considering a concrete case. If for a given operation the current required is 200 amperes, the total power used will be, if a 75-volt motor generator set is used, 200 amperes times 75 volts or 15 KW. In case the current is taken from a 500-volt circuit, the power required will be 200 amperes times 600 volts, or 120 kilowatts. Assuming that this amount of power is required for 50 per cent. of the total time, the kilowatt hours per operator per ten-hour day would be in the one case 15 x 5 or 75 KWH., and in the second case 120 x 5 or 600 KWH. Where the motor generator is used there will be, of course, a certain amount of additional power required to supply the no-load losses of the set when running light. Assuming these to be for the day 25 KWH. the total amount of power used in the first case would be 100 KWH., or 500 KWH. in favor of the low voltage equipment. At one cent per KWH. the difference would be $5.00 per day, or, in 300 days per year, $1500 saved by the use of the motor generator set.

The foregoing figures are, of course, very approximate, but even if the power cost should be only one-half cent per KWH., the saving would still be in the neighborhood of $750, and the purchase of the low voltage motor generator and equipment would be justified as the first cost of such an equipment for one operator would not over $1000 to $1200.

Marine Repair Work

An industry of comparatively recent origin is that of the repair of marine boilers. Practically every large harbor now contains one or more repair barges. These barges are equipped with an arc welding equipment and a compressor for furnishing air for sand blast and pneumatic tools; they are employed in the repair of the boiler equipment of vessels that may arrive in the harbor in need of such repairs. The barge is brought along side the vessel while the latter lies at the dock; cables and air hose are carried through convenient port holes to the point where work is to be done, thus enabling the necessary repair work to be accomplished without any loss of time on the part of the steamer. The methods used are much the same as in corresponding work mentioned heretofore.

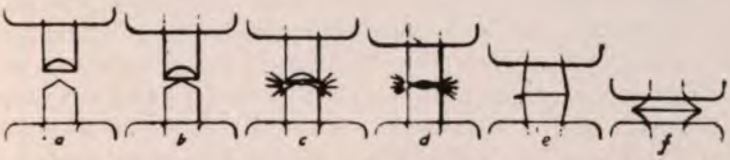

Fig. 17.—Successive steps in producing weld by electro percussive welding.

General Repair Work

There are a number of minor applications of arc welding equipment, among which may be classed general repair work in large shops, work in steel plants, cutting up scrap, etc.

Industrial plants employing a large number of machines will oftentimes be able to reduce their maintenance expense very considerably by the use of arc welding equipment. Repairs to be taken care of in these shops consist of broken shafts, worn journals and keyways, broken gear-teeth, worn rolls, etc., etc. The welding equipment may be installed permanently and wiring carried to different sections of the shop where welding is likely to be required, or the repair equipment may be made portable and suitable con [illegible] or the motor end of the equipment arranged for [illegible] d. Still another method is that of installi[illegible] wiring permanently, and using a porta[illegible] is connected to the circuit by pl[illegible] to be done.

Mention has already been made of the cutting off of risers on heavy castings in steel foundries. This work is done by the use of the carbon electrode with heavy currents. Risers may be cut off very rapidly and without removing them from the sand if desired. This method is far cheaper, in the case of the large castings, than the use of oxy-acetylene or the cold saw.

In steel mills still another point where the welding equipment is of value, will be found. It occasionally occurs that the tap holes or tuyeres of blast furnaces will become plugged with cinder or cold metal. Without the use of the electric arc, this would necessitate in many cases the loss of the heat and the closing down of the furnace to allow the chipping out of the slag or metal by hand, which is a very slow and tedious process. By the use of the carbon electrode, however, the obstruction may be cut away so rapidly that in most cases operation of the furnace need not be suspended. The carbon electrode is used and heavy currents, around 750 to 1000 amperes, may be employed. Where the obstruction consists mainly of metal, it is only necessary that one terminal be connected to the furnace so that a path of reasonably low conductivity to the obstruction is secured. Where, however, cinder is present in such quantities as to make the obstruction of high resistance, it may be necessary to drive an iron bar through the cinder in order to obtain satisfactory results, the bar being melted away and with it the cinder. With currents as indicated in the foregoing, the hole may be opened at a rate of about 30 inches per hour.

Manufacturing

The arc welding process has been found by experience to be very well adapted to certain classes of commercial manufacturing operations, replacing smith welding and showing very great savings. An example of this may be seen in the case of the large electrical manufacturing company with which I am connected. Here certain lines of motors and generators are constructed almost entirely of steel; the yoke or frame ring is made by rolling a slab of open hearth steel around a mandrel. This, of course, leaves a gap which must be closed and the carbon electrode process is used for this work. As to the quality of the work, it is found to be fully equal to that produced by fire welds, both from the standpoint of a homogeneous weld and from that of ease of subsequent machining. Similar applications can be found in very many metal working plants.

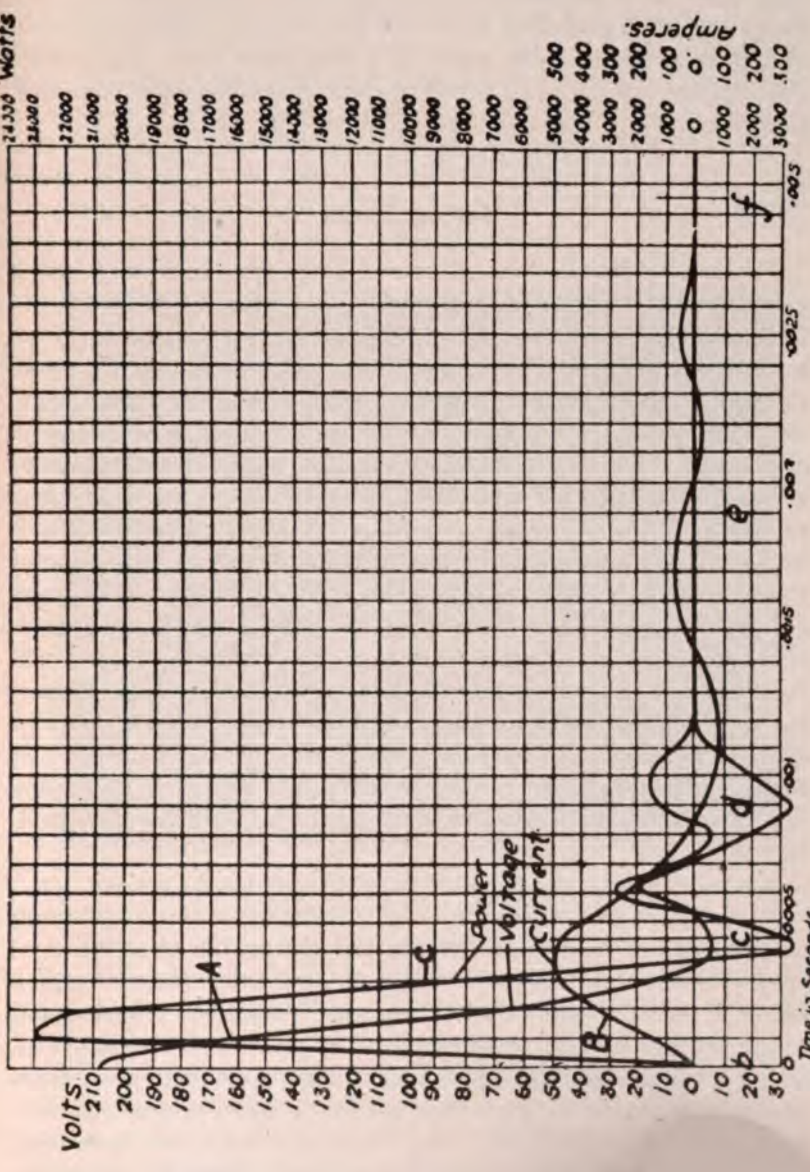

Fig. 18.—Oscillographic record of electro percussive
B, C, etc., refer to corresponding steps as shov

It is not to be inferred from this that arc welding is a manufacturing operation primarily, as such is not the case. Its greatest field of usefulness lies in repair work, as distinguished from incandescent welding, which is not at all suited to anything except repetition work, as in manufacturing quantities of duplicate pieces.

Installations

The earlier installations of arc welding equipment employed a motor generator for each operator, but this method was soon found to have several disadvantages in shops where two or more operators were to be employed. In the first place electric arc welding is essentially an intermittent process and experience has shown that the arc will be in actual use not more than 50 per cent. of the total time in most cases. From this it can be seen that the load factor of the motor generator would be low and that the cost of power would be correspondingly higher. In the second place, such an installation is necessarily more expensive in first cost than one employing a motor generator of sufficient capacity to supply all operators within a reasonable range and it would also be more expensive as far as regards maintenance. Again, the efficiency of the smaller equipment will necessarily be lower than that of the large unit. The general practice now followed is that of installing a motor generator of sufficient capacity to supply all operators within a range of 500 to 600 feet of the set, permanent wiring being installed and panel outlets for the individual operators located at points where it is desired to do welding.

A word as to the size of outfit required may not be amiss.

No hard and fast rules can be laid down, as no two installations will be alike in their requirements, and the matter of selection of apparatus of proper capacity is largely one of judgment and experience. It may be said, however, that in general for miscellaneous repair work around large industrial plants a 300-ampere equipment, which is of sufficient capacity to take care of two operators on metal electrode work, or to do, where necessary, light carbon electrode work, is usually satisfactory. For electric railways for track work, a 200 or 300-ampere outfit will be found to be about the proper size. In the repair shop, the track repair outfit may be used or a separate outfit may be installed if conditions justify it.

In steam railroad shops installations are usually made of sufficient capacity to take care of not less than four or six operators and the larger shops can occasionally use even greater capacities to advantage. Where a greater number of operators are to be supplied, however, it is generally found to be more economical to install additional outfits in other sections of the shop where welding is to be done, rather than put in one large central plant. This is on account of the fact that as this work is usually more or less scattered the cost of line copper becomes an item for consideration.

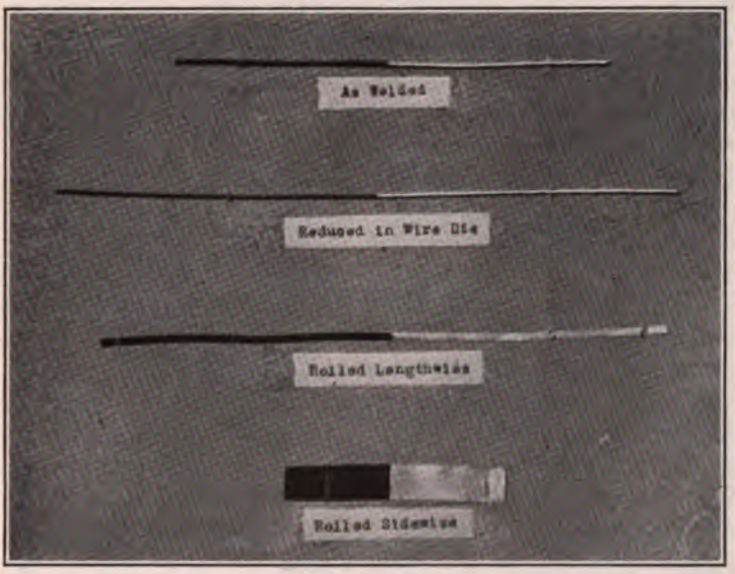

Fig. 19.—Copper and aluminum wires welded by electro percussive process, showing various tests made.

In steel foundries and steel mills, outfits of 800 to 1000 amperes capacity are usually installed. These are large enough to take care of six or eight operators on metal electrode work, respectively, but most of the operations found in these industries will be performed with the carbon electrode and the large capacity will be found advantageous in that it will enable more than one operator to be employed using the carbon electrode, or, when necessary, the full capacity of the machine can be concentrated at a single arc, thus enabling extremely rapid work to be done.

Incandescent Electric Welding

We come now to a consideration of the other main branch of electric welding, namely, incandescent welding.

"Incandescent or resistance welding, as it is sometimes called, is based upon the well known fact that in an electric circuit the introduction of resistance such as is made by a poor contact or conductor, tends to produce heating. There are two distinct processes of this kind, namely, the Thomson and the LaGrange-Hoho, of which the former is almost exclusively used.

The Thomson process is due to Prof. Elihu Thomson and, as stated in his original application which was granted in 1886, 'the invention consists in a novel art or process of and apparatus for forming joints between metal wires, bars and the like by the agency of an electric current.' (Mr. C. B. Auel, American Machinist 1914.)

Present commercial processes of incandescent welding, usually spoken of as spot or butt welding, are based on the original Thomson patent. This method will be referred to again in more detail.

The LaGrange-Hoho process, sometimes spoken of as the "water-pail forge," is not, so far as it is possible to ascertain, in use in this country today. "In this process an electrolytic bath is employed made from a solution of carbonate of potash and borax in water * * *. The Metals to be welded are fastened to the negative terminals of a direct current circuit of 125 to 150 volts, while to the positive terminal is fixed a comparatively large plate of lead, carbon or other suitable conductor. Upon passing current through the circuit the electrolyte commences to decompose, depositing apparently hydrogen on the metal pieces and so developing a gaseous resistance at the points of contact with the liquid. This resistance causes the metal to heat and finally to become incandescent.

The disadvantages of this process when compared with the Thomson process are apparent, as in the latter the same work is accomplished in substantially like manner without the use of the bath, which item is at all times a nuisance." (Mr. C. B. Auel, American Machinist 1914.)

Referring again to the Thomson process, the apparatus required consists of a source of alternating current, a transformer arranged with a primary coil of suitable characteristics for connection to the A. C. source, and a secondary coil arranged to give exceedingly large currents at potentials varying from one-half to 7 volts. The secondary

winding of the transformer, since it must handle very heavy currents, is made massive and usually of only a very few turns. Connections are brought out from the secondary circuit to heavy clamps or jaws, water-cooled in the larger sizes, into which the metals to be welded are inserted and gripped. The adjacent ends of the metals which are to be welded are carefully filed and butted together. "Upon closing the primary circuit, current flows through the metals, heating them rapidly at their point of contact to the fusing temperature. While in this softened condition they are forced together either automatically or by hand, thereby uniting perfectly. The shoulder which accompanies each weld is readily removed by a hand file, although on certain classes of work an automatic hammer and anvil are employed for the purpose."

This process has been steadily developed since its inception in 1886 until it is now utilized in an infinite number of ways including the joining of wires or rods of the same or even of dissimilar metals, the making of chains, tires and cylinders, the bonding and welding of rails, the uniting of pipe, the annealling of armor plate, the welding of high speed steel to machine steel, the manufacture of boilers, car wheels and the like.

The amount of current used for any given weld is regulated either by a rheostat or choke coil under the control of the operator, so that heating may be accomplished slowly or quickly as desired.

The heating commences at the center and progresses outwardly; there is no wasted energy. Further, as no foreign substances are used to produce the heat of fusion, such as coal, coke or gas, as in other processes of welding and as no flux is employed, there is no deleterious action upon the metals from these sources. Moreover, there is no change in the electrical conductivity. Tests as to the tensile strength of the welded material indicate that there is a weakening of the metal either directly at the weld, or more usually at a short distance to one side of it, the reduction being given by various investigators as 20 to 30 per cent.

The two classes of work taken care of by the Thomson process are known usually as "butt" and "spot" welding. "Butt" welding is used for welding wires, rods and bars end to end. This guished from spot welding where the two metals are spots thus securing the two pieces, much as is the Spot welding is coming ino very extensive use at taking the place of rivets on thin work. One of tl

spot welding is known as ridge or point welding. In this method, one or both of the pieces to be jointed are indented either in points, ridges or knobs. "After indenting, the pieces are placed together so as to bring the raised portions into contact and they are then squeezed between the jaws of the welder. Current is then sent through the circuit and the pieces at their points of contact are rapidly brought to fusing temperature. An extra squeeze between the jaws when in this softened condition completes the weld.

"Where it is not convenient to raise projections on the pieces, a metal button may be used instead. The pieces are simply slipped over each other and a small metal button is laid on top and pressure and current applied simultaneously. When the metals have softened, the button is forced right into the two pieces, the effect being precisely as if a rivet had been used." (Mr. C. B. Auel, American Machinist 1914.)

"An interesting application of the incandescent welding process is that of welding street car rails. Some illustrations of this process will be shown later. For welding rails, about 30,000 amperes at 5 to 7 volts are required for two or three minutes, with a pressure of approximately 4000 pounds per square inch, the greatest pressure being exerted when the fusing temperature is reached. Three welds are made at each joint in a total of fifteen minutes, the area of each being about 3½ square inches. With six men to operate the equipment as many as eighty welds have been made in twenty-four hours." (Mr. C. B. Auel, American Machinist 1914.)

This method of rail welding is usually utilized by electric railways where a 600-volt direct current supply is available from the trolley. Through a rotary converter the necessary alternating current is obtained, the A. C. output from the rotary being sent through a transformer, which gives the low potential and high current necessary for doing the work.

Electro Percussive Welding

Probably the most recent commercial development in the field of electric welding is that of electro percussive welding. This process is a modification of spot welding and its practicability was discovered in 1905 by L. W. Chubb and developed by the W. E. & M. Company to a point where it is thoroughly commercial. Although this process is related to that of incandescent welding, it is distinctly different

in a number of features. In the first place a source of direct current power is required, while in the Thomson process alternating current is used. Also the weld is practically instantaneous by the electro percussive method, while a distinct interval of time is required to allow the metal to heat where the Thomson process is used. Again, by the electro percussive process dissimilar metals, including those which are not ordinarily susceptible of being welded, can be successfully joined. An example of this is in the welding of aluminum wires or of copper to aluminum, copper to platinum, etc., etc.

The electro percussive process as at present developed is designed to take care of comparatively small sections only, but the application to larger sizes is only a question of the design of suitable apparatus.

Briefly, the electro percussive process of welding depends upon the discharge of a high capacity condenser through the points to be welded, together with a forging effect which is practically simultaneous. The apparatus required consists of a direct current generator, a condenser, usually of the electrolytic type, suitable resistors and inductors, together with a forging machine or welding tool.

"The process of welding is as follows. The wires are secured in the wire grips and the ends cut off as short as possible with a suitable pair of cutters. A switch short-circuiting the condenser is then opened, which charges the condenser to the proper voltage. A catch is then released, which lets the sliding member of the welding tool fall and brings the ends of the two wires into percussive engagement. At the instant of contact the short circuited current of the condenser goes up to such a value that the ends of the wire are melted by the explosive discharge and instantly forged together by the blow of the falling mass. The weld is then complete and after being removed from the machine will be found to have the strength of the original wire.

"The generation of the heat is so localized, so sudden and so intense that there is no time for unequal heat conduction through the shanks of the wire and the ends will be melted and even [illegible] whether the melting point is high or low. For this reas[illegible] different kinds can be welded together independen[illegible]al resistance, melting point or heat conductan[illegible]on of metals which has ever been tried will we[illegible]ints will not be permanent with such combina[illegible] tin or lead and iron.

"The generation of heat at point of contact depends upon having an appreciable resistance offered to the current at the wire ends and it is therefore necessary to cut the ends of the wire in such a way that they will make a point contact, preferably at the center, so that the energy of the condenser will vaporize a small section of metal and melt the rapidly approaching surfaces with the intense heat of the arc. To do this the wires are cut with ordinary pliers, which give a chisel edge. The two wires are cut off in such a way that the two chisel edges are at right angles and the point of first contact will be at their intersection at the center.

"The curves which will shortly be thrown on the screen show the current through and the voltage across the weld during the operation of welding at No. 18 B & S gauge wire. These curves were taken directly from an oscillogram and the power or products curve has been figured and drawn in. Electrically the weld is complete in .0012 seconds and although 23 kilowatts are being dissipated between the ends of the wire at a certain instant, the total energy use at the weld is only .00000123 KWH. or enough to light an ordinary 50-watt, 16 candle-power lamp for .09 seconds. The cost of this amount of energy at ten cents per kilowatt hour would be twelve millionths of a cent. The letters a, b, c, d, e, f, have been placed along the time axis of this curve to approximately indicate the time corresponding to the various views of the work shown in another slide.

"It will be noted that the watt curve is oscillatory and that the negative values would indicate a return of stored energy. Such a thing would be impossible with a metallic arc, but it can be explained by saying that the voltage was measured above and below instead of between the wire chucks and the storage and return of energy is from the magnetic flux produced in the steel chucks set up by the current of 500 amperes flowing through them." (Skinner & Chubb Proc. Amer. Elec. Chem. Soc. 1914.)

The inclusion of an inductance in series with the condenser and the electrodes may at first sight seem peculiar. Its purpose, however, is to prolong the current until the final contact of the metals and prevent the explosive snap, due to a condenser discharge with small inductance in circuit. Without this inductance, it has been found that a very high frequency oscillation is obtained, causing an explosive discharge and due to the nature of the electrolytic condenser, the current is suddenly damped and as the arc goes out before final con-

tact, the wires will not be hot enough to form a good weld. The inductance, therefore, serves the purpose of lowering the frequency of the discharge and prevents the rise of current at the first instant of contact being so sudden as it would be without this inductance.

When the adjustments of inductance and resistance are properly made, the condenser discharge at the moment of contact sounds like a splash or thud instead of a sharp crack. With a certain amount of experience the operator can guess at the settings and it will not be necessary to make any trials. As to the mass and drop of the falling chuck, it must be sufficient to slightly forge the wire. After the setting is once made for any given work, the machine will make a perfect weld every time and the speed of turning out work will only be limited by the handling of the product.

One of the chief advantages of electro percussive welds lies in the fact that they can be made without any apparent change in the properties of the two metals being welded.

"Tempered spring steel welded, reduced to uniform diameter, and tested has shown equal or greater strength at and near the weld without any noticeable change in temper. Metals such as hard drawn copper, silver, aluminum, etc., which softens with heat, can be welded together without causing any local annealing, and these metals and steel when soft can be welded together without detrimenal local hardening.

"Several possible explanations of the constancy of the mechanical properties before and after welding can be given. First, such sudden heating and cooling may not allow change in molecular structure. Second, with hard steel, the heated metal at the weld is so suddenly cooled by conduction of heat into the two shanks of metal that it is again hardened. Third, with hard copper, silver, aluminum, etc., the heating and sudden cooling would ordinarily soften the metal, but the cold forge of the blow in welding possibly hardens it again. Fourth, the metal subjected to the sudden heat cycle may be hardened or annealed (depending upon the characteristics of the material welded), but the amount of material affected may be too small to be detected. As an example, assume a No. 18 hard drawn aluminum wire to be welded together, 0.00123 watt hour or 1.06 small calories are dissipated at the welds. Assume none of the energy lost in n
heat or metallic vapor, and one-half of the total propa
wave in each direction along the wire. It can be s

ically that an annealing temperature will not be reached more than 0.05 mm. from the weld. The total amount of metal softened would then be a cylinder or disc 0.1 mm. long and 1.02 mm. in diameter. A soft insertion of such proportions could hardly be detected. Actual micrographs show that in a case exactly similar to that under consideration the disc of changed metal is only about .01 mm. instead of .1 mm. thick and physical tests fail to show any weakness or softness at the weld after being reduced to uniform diameter by removing the surplus metal of the burr.

"Many of the alloys of most metals are very hard and brittle. As an example, there are alloys near both ends of the copper-aluminum series which are unworkable, and yet electro percussive welds between these two metals are so ductile that they may be worked in a die, forged, or rolled into thin foil. Any alloy formed at the weld must range from 100 per cent. copper on one side to 100 per cent. aluminum on the other; but possibly the brittle combinations are so thin that the joint as a whole is flexible and ductile. This joint between aluminum and copper is of great importance, as copper lead wires, which solder and connect easily, can be readily attached to aluminum coils. At first it was feared that a diffusion of the two metals in service would finally result in a brittle joint, but tests show that after four years the joints are practically as strong and ductile as when first made." (Skinner & Chubb, Proc. Amer. Elec. Chem. Soc. 1914.)

Another feature of particular interest in this process lies in the fact that the electrical resistance of two wires welded together by this process is not not appreciably increased. A test made on a wire composed of 85 alternate pieces of aluminum and copper joined with 84 welds in a total length of 23.5 cm. showed an increase of .56 per cent. in resistance in three years. This increase is small and it may have been due to a change in the joints or possibly to an error of observation or to oxidation of the wire. The sample in question was rolled and its malleability indicated no appreciable change.

The electro percussive method of welding has opened up a wide field of application hitherto impossible. Although the process was first developed on account of the necessity for finding some means of satisfactorily joining copper and aluminum, its applicability has been found to be much wider than simply to this one process. When it is considered that such widely differing metals as platinum and tin or aluminum and tin are easily welded, some idea of the work which

is possible may be obtained. In addition to the welding of wires together enough work has been done to demonstrate that other welding may be successfully done, such as the welding of points to plates and small pieces to irregularly shaped objects or flat surfaces.

Among the applications of electro percussive welding which have already been made, there might be mentioned the joining of aluminum wires; the welding of copper and aluminum wire; platinum and nickel; platinum and copper; and the welding of various types of thermo-couple wires. It has also been used for the reclamation of short pieces of wires of various kinds, such as aluminum, platinum, spring steel, etc.

"The electro percussive method is suitable for many applications in the jewelry trade, such as the joining of platinum without showing any solder line; the welding of sterling tips to table forks without annealing; the welding of pins to badges, and many other similar applications. The attachment of contact points of tungsten, silver, etc., for various electrical purposes is also very readily accomplished."

In conclusion, it might be said that this method, although it overlaps some of the older processes of welding, meets entirely different requirements and that it will probably never replace these older methods for heavy sections.

DISCUSSION.

Mr. Wm. H. Gravell: I would like to ask why A. C. cannot be used for arc welding?

Mr. Bryan: We have tried A. C. for arc welding and the trouble has been that the arc is very unsteady, and it is also very noisy and hard to handle. The arc has a tendency to go out as the current passes through zero, so that it is found impossible to work with A. C., except with the carbon electrode and using heavy currents, 500 amperes or more. As compared with a direct current, the amount of heat is less for the same amperage. Thus far it has not been found to be a commercial proposition.

Mr. Gravell: Can the metallic circuit be maintained?

Mr. Bryan: I do not believe it can.

Mr. H. J. Hartley: Have you any data as to the average percentage of strength at the weld as compared with that of the solid metal? The question of strength is the vital point in all manner of welding processes.

Mr. Bryan: I have not any printed matter with me. The weld will be found anywhere as low as 65 to 70%, or in the case of a poor operator, where it is the operator and not the process at fault, I would consider the average about 80%. Of course with a double lap weld, welding both ends, we would get efficiencies as compared with a single thickness of the sheet of 100%; it would in some cases run over 90%.

Mr. H. H. Quimby: I would like to suggest the desirability—the practicability—of substituting electric welding in the fabrication of structural steel work for riveting in connecting different portion of a member. Take the case of a plate girder, it would be desirable if the flanged angles could be welded to the web plate instead of being riveted to the web plate, because in the design of structural steel work where heavy stresses intersect every point, a very large amount of metal must be added, which is useful only for the purpose of getting connections—only for the purpose of getting an area in which to get in sufficient rivets for connecting. I think it is figured roughly that the largest percentage of contact between the flanged angles and the web of a girder is about 1/15th of the area; the largest percentage of area that we can supply rivets for shear. If we can unite both edges of an angle to the web plate for a depth of ¼" we will have an angle for the shear. If you could largely increase the area of the girder, we could largely decrease the length over which it would need to be applied, and consequently largely decrease the amount of metal that is entirely useless for any other purpose.

In another way it would help us to save metal. We sometimes have put in a good deal of metal in a casting for the sake of getting bearing area, and I would judge it would be practicable to unite a filler to the edge of a flanged angle to get bearing, and we could concentrate our stresses very much more, and therefore save a large amount of metal. Has any such work ever been attempted, and is it practicable?

Mr. Bryan: I will take up the last part of the question first, that is as to whether any such work has been done. I do not know of any place where it is being done commercially, although I believe that some companies are considering the matter in a preliminary way at the present time. I believe that the proposition can be worked out, possibly by arc welding, possibly by spot or butt welding, or by a combination of the two. I believe that the use of arc welding as a reinforcing medium will enable you to reduce the number of rivets required. With reliable operators I see no reason why it should not work out satisfactorily and enable you to cut down your rivets, or possibly to eliminate them entirely. However, I believe that a good many engineers would be unwilling to use welded structural material without having more complete data than is available at present. Some classes of riveted work will undoubtedly be taken care of eventually by arc welding.

The power required for electro-percussive welding will, of course, be determined by the size of the weld, but, as a matter of fact, it is very small and almost indeterminable except by the oscillograph. Of course, the generator itself needs to be only of small capacity.

Mr. Parsons: I see that welding is used in metal furniture. With the equivalent of your flanged angle you get a better contact over a sheet which is warped, and you can stiffen it and get good results.

Mr. H. H. Quimby: I should think that the connection would be better with heavier metal. That sounds very promising. I know that the welding process—electric as well as gas—is used in the manufacture of railings and grill work, and is said to cost much less than the old method of riveting, in fact, you can get designs that would be unreasonable in cost if drilled and riveted.

Mr. E. M. Nichols: I would like to ask Mr. Bryan what is the amount of power used on certain areas. Supposing you wish to weld two pieces of steel ½" in diameter, how much power would it require by the percussive method?

Mr. Bryan: Mr. Nichols has asked me a question that I am unable to answer offhand. The electro-percussive process has not yet been developed for welding rods as big as ½" in diameter. The process has been used on wire up to ⅛" or possibly a little larger; for cross sections larger than that the butt welding process would seem to be generally more advantageous.

Mr. Nichols: Only light work has been done so far.

Mr. Bryan: Yes, that is for lighter sections. In that connection I might mention one use which has been made of the electro-percussive process, that is in splicing aluminum transmission cable. From an electrical standpoint it is difficult to make good splices with aluminum cable, due to the film of oxide which is always present with aluminum, and if great care is not taken in the making of the joint, you will eventually have a joint which will have high enough resistance to burn the splice out. We get around this by making splices of copper, by welding copper ends on the individual strands of the aluminum cable by the electro-percussive process, thus making an absolutely permanent job of it. We have made joints between copper and aluminum wire by the electro-percussive process and on testing them after three years, the change in resistance was less than ½ of 1%, which might easily be an error of observation, or caused by oxidation of the conductor itself. That is one field of application that has been taken care of by this process.

Mr. Parsons: I would like to ask what is the relative difference between this and one or two of the modern processes, like the Siemund process, for instance. Is there any material difference, I mean technical difference?

Mr. Bryan: There is little. The basic design of all arc welding equipment is more or less similar. There are a number of schemes on the market today which are different in detail, but this difference is only in the design of the control. The company which I am connected with maintains—after fifteen years' experience—that the simpler the process is, the better are the results when considered from all standpoints, i[illegible] cluding that of maximum production, minimum operative cost and l[illegible]

maintenance expense. We have continually held to the idea of simplicity, and the result has been that we have produced an outfit that is capable of taking care of any requirements to be met in welding, without the use of complicated automatic features; this has been proved by installations not only in our own factory, but also in the case of about fifty outfits of our make which are installed all over the country.

Mr. Parsons: You have not mentioned fluxes very much.

Mr. Bryan: The question of flux is a point on which there is a very large difference of opinion. Manufacturers of some machines on the market claim that flux is a necessity. On the other hand, some operators say that they cannot get as good results with the flux as without. Personally, I think it is largely a matter of personal equation of the operator. Our own experience has been that flux is not required for ordinary work on wrought iron or steel. For welding cast iron we do use flux and find that it helps get better results. There is a process on the market, brought to this country within the last few months, that seems to be producing very good results on special work. I have no axe to grind in referring to them, but from what I have seen, I believe that this process which uses a special coated electrode and which is known as the Quasi Arc Process, will enable better work to be produced in some cases than can be obtained with bare electrodes. It is considerably more expensive than bare electrodes, but where manganese steel is to be welded they seem to get very good results.

Mr. Gravell: In welding very thin metal, say 1/16″ down to perhaps .30 mm. in thickness, or for ⅛″ iron, we adopted the use of a mixture of calcium fluoride, and the arc does work very much better by the use of the flux. The flux is an advantage in very thin metal, but in larger metal I do not think it is an advantage. I know that the Baldwin Locomotive Works, however, do use a flux in welding cast iron.

Mr. J. F. Lewis: The illustrations of the larger specimens we saw tonight were welded completely across their edge, and if several pieces of metal were placed with their edges together they could be welded along their edges.

While Mr. Quimby was talking I was thinking why could not light structural work be welded together rather than riveted? The problem presented itself to my mind in this way:

Take two plates, 8″ square, and place them together; now if the place where the current passes from one plate to the other can be concentrated at one point, say the center of the plates, this point will become the hot or fused point and the plates will be welded together there. This weld at the center would act the same as a rivet at the center. If this can be done in one position, as at the center of the plates, it could be done in four or five positions with a proper increase in current. If the two plates are flat and were placed with their flat sides together, such as we find in structural steel fabrication, and one electrode fastened to each plate the current would then pass between the plates over the entire area of con-

tact. The contact resistance would be too low to develop a welding heat without the use of an excessive current and the use of such a large current would possibly destroy the shape and structural value of the plates. I think the welding could be done by concentrating the points where the current would pass from one plate to the other. These points would have a small contact area and a large contact resistance and the heat would be developed at these points. These points could be secured by giving the plates an indentation at the proper positions. When the heat is developed by the current the plates could be pressed together and a condition would result which would virtually be a riveted condition of the plates. This is just a little vision I had, and I wonder whether anything has been done in that direction.

Mr. Bryan: I would say that that ought not to present any serious difficulty to manufacturers of incandescent welders. What thickness were you thinking of?

Mr. Lewis: Say up to ¾" or ½".

Mr. Bryan: I see no reason why that could not be done, possibly by indenting the plate, or using a button method, or even by simply using spot welding without indentation or a button in case the metal is fairly thin. The weld would constitute a rivet in itself. I think that is a practicable proposition, one, in fact, that is being done every day; for instance, on rail work you are welding a section that has about 3½ square inches in area.

Mr. T. M. Chance: I think that the suggestion of Mr. Quimby in reference to the substitution of some system of electric welding for riveting in the fabrication of structural members is exceedingly interesting. There is one phase of the question, however, that I would like to call attention to, and that is the difficulty of being sure of the physical properties of the resultant member. The same feature has presented itself in reference to various systems of welding boiler headers and steam nozzles, but with this difference, however, it is entirely possible to blank off such a header and test it hydrostatically to a pressure far above its rated load, so that we may feel reasonably confident that such a tested header would not subsequently fail. In the case of structural members we do not have this advantage, especially where the work would involve large complicated members, as in the fabrication of heavy girders, and while the member might appear to be structurally perfect, it might not be entirely so, and, if a poor piece of welding had escaped the inspector, somewhat unfortunate results might follow its use.

Mr. Bryan: The point you make is well taken, that is in a case of that sort. Where work is entirely out of sight, as it would be in steel building, you would want to be reasonably certain of your operator and be able to depend upon him. In the final analysis, the operator is a b factor in producing dependable work. A poor operator can produce v looks like pretty good work, but a good operator will turn out work looks very much the same, but where there will be a very deci

ference in strength. Here you want to get the right man for this kind of work, a man who will not be satisfied at anything short of the best results. That is the case in arc welding. In spot and butt welding the personal factor of the operator does not enter in so much, as not a great deal of skill is required in handling the machine. A great many people have an idea that arc welders ought to be able to turn out absolutely perfect work after a couple of days' practice. The same people would not expect a man to be an experienced blacksmith in anything like this time. As a matter of fact, the skill required to produce first class work is far more easily and quickly obtained in arc welding than in blacksmith welding.

Mr. T. M. Chance: Sometime last winter the question of waterproofing some subaqueous concrete work by means of a cast iron plate shell arose. One of the concerns interested in electric welding in this country wished us to consider welding these plates on their outer edges instead of using machined flanges cast on the edges of the plate and bolted up with gasket-packing. They also wanted us to let them estimate on welding the plates to the structural members in the concrete instead of bolting these plates thereto. The process which they contemplated using consisted in the application of a cast iron pencil electrode. In taking the matter up with them we endeavored to ascertain whether this cast pencil which was to furnish the metal for use in the space left for welding would not lose a portion of its carbon during the process of welding. The reason this was of interest to us was that if such carbon loss occurred we might readily get serious electrolytic action between the higher carbon cast plates and the lower carbon welds. Has any work been done along that line? And if so, has it been found that corrosion takes place when such welds are subject to the action of salt water?

Mr. Bryan: How thick were those plates?

Mr. T. M. Chance: About ½". They figured within 2% of what it would cost to make those flanged plates finished on four sides.

Mr. Bryan: In metal electrode welding you are going to lose a small percentage of your carbon. As to the total loss of the carbon content, I am not prepared to say positively, but I believe that with cast iron plates of that sort, it would be better to use carbon electrode and cast iron filler rod. Where cast iron filling material is used you would get practically a cast iron weld with the same carbon content as was in the filler. I believe that you can get a more homogeneous weld on this sort of work by using the carbon arc and a cast iron filler than you can get with the metal electrode.

As to corrosion from salt water I am not very well posted on that point. I do know that metal electrode welding is being used for the manufacture of mines. Those mines that are floating in the North Sea are made of boiler plate sheets which are welded with the electrode arc.

Mr. T. M. Chance: They are steel?

Mr. Bryan: Yes, they are steel. I believe that some experimental work will help to figure out a combination which will work out so as to

get away from corrosion, due to possible electrolytic action, between the weld and the original material.

Mr. E. M. Nichols: How thick plates can you handle? As Mr. Quimby asks, suppose you wanted to put two angles on the bottom of each web plate.

Mr. Bryan: The whole proposition depends upon the size of your welding machine—you are referring now to spot welding, I believe. Probably ⅞" or 1" would be the thickest that could be welded without a very big machine. It would take currents running into the thousands of amperes.

Mr. Nichols: Does the surface of those metals have to be prepared?

Mr. Bryan: For spot welding no special preparation is necessary beyond cleaning off the scale so as to leave the metal clean. In arc welding you can clean the work as they do in steam boiler work, by using a sand blast, but on work on castings the carbon electrode could be used to melt the surface so that sand and other impurities will run off, leaving clean metal. It is one of the essentials of arc welding to see that you have clean bright metal, and that you have no dirt or scale to be covered up in the weld.

JOHN BIRKINBINE

Mr. John Birkinbine ended a long and useful life at his home, at Cynwyd, near Philadelphia, on Friday afternoon, May 14th, 1915. Simple funeral services and private burial on Monday, the 17th, were in accordance with his ideals, but men from all walks of life and various organizations came, wherever possible, to show their respect and esteem.

For over half a century he carried forward a name well known to the engineering profession, being the eldest son of the late H. P. M. Birkinbine, who was widely recognized for his ability in hydraulic engineering. As a young man he had charge of much of the field work and construction for his father, with whom he was later associated in the design and construction of public water supplies, water powers, etc., and continued as a consultant or expert in such matters.

His education was received at public schools and the Friends' High School in Philadelphia, the Hill School at Pottstown, Penna., and the Polytechnic College of Pennsylvania. His studies were interrupted by military service in 1863-4 on scout duty with the Union Army, under two enlistments, participating in the engagements at and around Gettysburg. Later two years were devoted to practical work in a machine shop, and subsequently he was associated with the late P. L. Weimer as the firm of Weimer & Birkinbine, which operated the Weimer Machine Works, at Lebanon, Penna.

Much of his work has been in mining, metallurgy and blast furnace construction. As manager for the South Mountain Mining & Iron Company he carried on experiments with various fuels for iron ore smelting while maintaining the furnace in constant operation. The carefully recorded results obtained were widely published, and are referred to in text books by other metallurgists as being the most complete made.

From his Philadelphia office he has been sent to nearly every state, and to Canada and Mexico, for examinations, reports, constructions of or improvements to iron ore mines, blast furnaces, iron works, water supplies, hydraulic development, irrigation projects, etc., and his engineering knowledge has been requisitioned by several European Corporations. A number of business trips were made to Mexico, beginning with a visit to the Cerro de Mercado, at Durango, Mexico, before railroads were established in that portion of Mexico, to make a critical examination and report on this "Iron Mountain." Later visits covered other localities and engineering problems, familiarizing him with the major part of the iron industry in Mexico; and the late disturbed political conditions in our neighboring Republic have retarded the probable enlargement, modernization and improvement of much of the iron and steel industry of

Mexico, upon which he investigated and reported for various capitalists on both continents. One interesting feature of the above was a proposed electric furnace operated by energy from water power.

Mr. Birkinbine was probably the pioneer to suggest an iron industry at the head of the Great Lakes, using coke made from Pennsylvania coal, and his report was an important factor in establishing the iron industry at the head of Lake Superior, and the blast furnace at West Duluth, Minn., was built under his plan and supervision. He was engaged by the State of Texas to investigate the practicability of iron manufacture in the Lone Star State. As an engineer he co-operated with Mr. E. S. Cook, of Pottstown, Penna., who did much to advance the iron industry. He was for some years Consulting Engineer for the Philadelphia & Reading Coal & Iron Company, and held a similar position with Mr. Thomas A. Edison during the latter's early experiments on magnetic concentration of iron ore, and with Witherbee, Sherman & Company, in beneficiation tests. Also for the Colorado Fuel & Iron Company for the enlargement and improvement of their works and the construction of an augmented water supply system.

In his reports and recommendations his conclusions are clearly stated, and a reputation for conservatism and fairness has brought him numerous engagements in connection with valuations, adjustments and arbitrations, in some of which he has been the representative of both parties by mutual consent.

He has also acted as an expert for financial interests and for a number contingent fees whatever, and would patent none of his numerous improvements or ideas, so that personal bias in his statements or conclusions could not even be suggested.

He also acted as an expert for financial interests and for a number of the greatest industrial corporations and several large railroad companies in this country. He was Chief Engineer, Vice-President and Chairman of the Committee of Awards of the National Export Exposition, served on Juries of Awards at the Centennial, World's Columbian, Pan-American and Cotton States General Expositions, and was named for similar duties at others.

Since its inception, in 1905, he has been Chairman of the Water Supply Commission of Pennsylvania, patriotically devoting a large portion of his valuable time for a nominal recompense. As a result he established an efficient organization, not only free from political influence, but noted for the zeal and faithfulness with which each member carried out his duties.

He was active in forming the Pennsylvania Forestry Association, the largest and most influential of any state, and has been its President for twenty-three years, during which time the Association accomplished the

appointment of a State Forestry Commission (later made a State Department) and the enactment of statutes which encouraged the forestry movement. Since this Association was formed in 1886 he has edited its publications.

For two-score years he has been active in the American Institute of Mining Engineers, having been Manager, Vice-President and President, being re-elected to this latter office to the limit set by the constitution; and has contributed liberally to its proceedings and to other technical papers.

He was active in the formation of, and served as Secretary to, the United States Association of Charcoal Iron Workers, and for nine years edited its journal. For many years he was Special Agent for the United States Geological Survey, preparing the reports on Iron Ores for the Eleventh and Twelfth Censuses, and that on Manganese Ores for the Twelth Census, and has since prepared for the Survey additional data and studies. He was appointed by the Secretary of the Interior expert Metallurgical Engineer for the Bureau of Mines.

He has received marks of approval from the Survey and from several foreign scientific societies, and was a member of a number of international congresses.

For ten years he served as President of the Franklin Institute, the leading scientific society in the United States. He was also a member of the American Society of Mechanical Engineers, the Engineers' Club of New York, the American Society for Testing Materials, the Engineers' Club of Philadelphia (President in 1893), the Manufacturers' Club of Philadelphia, the Pennsylvania Foundrymen's Association, the George G. Meade Post No. 1, G. A. R., of Philadelphia, and was an Honorary Member of the Canadian Mining Institute.

Mr. Birkinbine refused honorary degrees from two colleges, modestly stating that, as he had been unable to graduate from his own Alma Mater, he was not warranted in accepting a higher degree.

During his career Mr. Birkinbine has also maintained his specialty of hydraulic engineering, acting as engineer on water supplies for various municipalities. He has not only witnessed, but has had active participation in, the development of water power for electrical energy. While he was at college, electricity was a matter of laboratory experiment only, and its first exhibition as an illuminant was at Philadelphia about twelve years later; while the use of water power was then confined to limited volumes at low heads for direct mechanical purposes. His activities have covered the development of hydro-electric science to its present advanced stage. In 1888 he prepared a comprehensive report on the development of the great water power of the St. Louis River in Minnesota, con-

sidering a 15-mile transmission, though no water wheel manufacturer would guarantee turbines for heads above 35 feet. Since then he has been associated with, or reported on, many developments in various states and in Mexico, covering high heads or large volumes of water until lately deemed impracticable.

Born in Reading, Penna., on November 16, 1844, Mr. Birkinbine early moved to Philadelphia, where as a young man he established, with his father, an office, now continued by his sons, the family trend to engineering thus being maintained for over sixty years.

Mr. Birkinbine always maintained a friendly interest in his fellow-members of the profession, and held to the thought that engineers were co-operators and not competitors. He continued his personal interest in all associates, and was ever ready to help young men by advice.

As a citizen he was always active in promoting the public good; he served on the Civil Service and other Commissions, as well as rendering professional services to the City of Philadelphia. His neighborly activities were maintained to the end of his life. His last days were happily spent among his family, for as a devoted and Christian husband and father he fulfilled what he considered his greatest pleasure and the noblest of all his works.

ABSTRACT OF MINUTES OF THE CLUB

BUSINESS MEETING, MAY 1, 1915

The meeting was called to order by President Ledoux, at 8.25 P. M., with 57 members and visitors in attendance.

The Minutes of Joint Meeting of the American Society of Marine Draftsmen, Delaware River Branch and the Engineers' Club, were approved as printed in abstract.

The Secretary announced that the American Institute of Electrical Engineers, Philadelphia Section; the American Society of Mechanical Engineers, Philadelphia Chapter; and the Illuminating Engineering Society, Philadelphia Chapter, were elected to Affiliated Membership of the Board of Directors at their last regular meeting.

Applications for Affiliated Membership were received from the American Society of Civil Engineers (Philadelphia Members) and the Technology Club of Philadelphia.

Announcement was made of a special meeting of the Club, to be held Saturday, May 8, 1915.

Paper—"The Transcontinental Telephone System," by Mr. P. C. Staples, Publicity Manager of the Bell Telephone Co.

Action on the Resolution endorsing the movement for a "greater Chamber of Commerce" was deferred until the next meeting, to allow the affiliated members to express their views regarding it.

Mr. Henry Hess, Past President, presented the paper of the evening entitled "Engineers as Municipal Executives," which was discussed by Messrs. Nichols, John C. Trautwine, Jr., Dr. H. M. Chance and others.

JOINT MEETING, MAY 15, 1915

American Institute of Electrical Engineers, Philadelphia Section and the Engineers' Club of Philadelphia.

The meeting was called to order by Past President Swaab, at 8.40 P. M., with 74 members and visitors in attendance.

The Minutes of the Business Meeting of the Club held Saturday, May 1, 1915, were approved as printed in abstract.

The Secretary announced the election of the following members:

Active Membership—Charles A. Brown, Walter A. Hall, William H. Hall, William B. Kugler, Willard D. Lockwood, John W. Meyer and Richard C. Newbold.

Junior Membership—William J. Doyle, Jr., George W. Wall, Jr.

Mr. Swaab then introduced Mr. H. F. Sanville, Chairman of the Philadelphia Section of the American Institute of Electrical Engineers, who assumed the chair and introduced the speaker of the evening, Mr. J. H. Bryan, of the Westinghouse Electric Co., of Pittsburgh, who presented a paper entitled, "Electric Welding," which was discussed by Messrs. Hartley, Quimby, Parsons, Nichols, Lewis, Chance and others.

Mr. John C. Trautwine, Jr., announced the death of Mr. John Birkinbine and gave a brief outline of Mr. Birkinbine's engineering career. Mr. Sanville announced that the annual banquet of the Philadelphia Section of American Institute Electrical Engineers would be held on Monday, June 14, 1915, at the Hotel Walton. .

ABSTRACT OF MINUTES
OF THE
BOARD OF DIRECTORS

REGULAR MEETING, MAY 11, 1915

Present: Vice-Presidents Vogleson and Yarnall; Directors Gibson, Hibbs, Wagner, Andrews, Dauner, Irish, Jones, the Secretary. Past Presidents Swaab and Taylor, and Director Sanville, representative of the A. I. E. E.. President Ledoux, Directors Worley, Moore and Bailey were excused. Vice-President Snook, Directors Dunlap, Bonine, Wilson and Horner (representative of the I. E. S.) were absent.

It was announced that Mr. Sanville, of the A. I. E. E., had been appointed to represent that Society as Director on the Board, Mr. Tracy to represent the Electrical Engineers as a member of the Meetings Committee; Mr. H. A. Horner is to represent the I. E. S. on the Board of Directors until October 1st, at which time he is to be succeeded by Dr. Crampton, Mr. C. H. Clewell to represent the I. E. S. on the Meetings Committee.

The Minutes of the meeting of April 13th were approved with the following correction: The words "on formal application" to be inserted on page 2 of the Minutes so as to read as follows:

> "The Philadelphia Section of the A. I. E. E., Philadelphia Chapter of the A. S. M. E. and the Philadelphia Chapter of the I. E. S. were, on formal application, elected to Affiliated Membership."

The Membership Committee's report was presented and approved, and the following elected:

To Active Membership: Charles A. Brown, Walter A. Hall, William Harrison Hall, William B. Kugler, Willard D. Lockwood, John W. Meyer, Richard C. Newbold.

To Junior Membership: William J. Doyle, Jr., George W. Wall, Jr.

The Secretary was instructed to advise the American Society of Engineers, Architects and Constructors regarding the action of the Board relative to the application for Affiliated Membership of that Society.

The following resolution, relative to Junior Members, was passed:

> Junior Members elected to membership prior to April 1st, 1915, arriving at the age of twenty-five years prior to April 1st, 1916, shall have the difference in dues for the current fiscal year remitted.

The President was authorized to appoint committees on Public Relations and Increase of Membership.

A tentative draft of the new application blank presented by the Secretary was referred to the Membership Committee, with power to act.

The application for Affiliated Membership of the Technology Club of Philadelphia, and the application of the American Society of Civil Engineers, Philadelphia Association of Members (to be received in the course of a day or so from this meeting) were ordered to be voted upon by letter ballot, a two-thirds vote of the Board of Directors being required to elect.

The Secretary was instructed to communicate with the Club's attorney regarding the number of votes necessary to make a legal quorum in the Board.

The death of A. M. Van Osten, on March 12th, 1915, was announced.

The death of W. Hunter, on April 2nd, 1915, was announced.

Mr. Yarnall reported for the Special Committee on Prospectus, and the matter was referred to the Committee on Increase of Membership, with power to act.

Regular Meeting, June 15, 1915

Present: President Ledoux, Vice-Presidents Vogleson and Yarnall, Directors Gibson, Hibbs, Wagner, Worley, Andrews, Dauner, Dunlap, Sanville, Humphrey, Swaab and the Secretary. Vice-President Snook and Past President Hess were excused. Directors Moore, Bonine, Irish, Jones, Wilson, Horner, Davis, Past President Taylor and the Treasurer were absent.

The Minutes of the Regular Meeting of May 15th were read and approved.

The Secretary announced that the Philadelphia Association of Members of the American Society of Civil Engineers and the Technology Club of Philadelphia, had been unanimously elected to Affiliated Membership.

The Secretary announced that several resignations had been presented, and asked instruction regarding the date on which these resignations could be accepted. The following resolution was passed:

> Resolved, That resignations presented during the year 1915 be accepted if dues are paid to the end of the present calendar year.

The Treasurer reported a net loss of $186.79 as compared with a net gain of $131.01 for the same period of 1914.

The Meetings' Committee presented a tentative list of speakers and titles of the papers to be presented. The report was approved and the Committee given full power to act.

The House Committee announced that, through the kindness of Mr. Edward Lupton, the Club now possessed a motion picture booth. A unanimous vote of thanks was extended Mr. Lupton for his gift.

The Membership Committee's report was presented and accepted, and the following elected to Active Membership: Frank D. Hamlin, Harold F. Hilts, John J. Tierney.

Mr. Yarnall spoke on the progress of the Committee on Prospectus and Increase of Membership.

Communication from Mr. W. Nelson L. West, attorney, was presented, in which he announced that a quorum should consist of a majority of members of the Board, as constituted.

The second Tuesday of each month was fixed as the regular date for the meeting of the Board of Directors.

The amount of $25 additional was appropriated to the Library Committee for the purchase of volumes issued by the International Engineering Congress.

Letters from the A. I. E. E., A. S. M. E. and A. S. C. E., regarding affiliation, were presented, and the Secretary instructed to codify the interpretation of the by-laws covering the questions raised in these communications.

Communications were received from the Philadelphia Association of Members of the American Society of Civil Engineers announcing that Mr. Richard L. Humphrey had been appointed to represent the Society on the Board of Directors and on the Meetings Committee of the Engineers' Club of Philadelphia; and from the Technology Club of Philadelphia announcing the appointment of Mr. Carleton E. Davis to the Board of Directors, and Mr. George Lees to the Meetings Committee.

The death of Mr. John Birkinbine, on May 14, 1915, was announced. The Publication Committee was instructed to prepare a suitable memorial for publication in the proceedings.

The Treasurer asked that a rule be established regarding the dues of non-resident Junior Members, which, under the new by-laws, are $12.50 per annum. The following motion was passed:

> That the Treasurer be authorized to remit the difference in dues between the former non-resident Junior dues and the present non-resident Junior dues, to April 1st, 1916 and that he notify non-resident Junior members of the change in by-laws, calling attention to the fact that the new dues would be operative April 1st, 1916.

Communication from the Second Pan-American Scientific Congress was received and the President was appointed to represent the Engineers' Club at this Congress in Washington, December 27th, 1915. In the event of his inability to attend he was authorized to appoint an alternate.

Communication on engineering co-operation was received from Mr. C. E. Drayer, of the Cleveland Engineering Society, relative to a Conference to be held in Buffalo, June 23rd and 24th, 1915. Messrs. Yarnall, Hess and Cooke were appointed as delegates to represent the Engineers' Club at this Conference.

Editors of other technical journals are invited to reprint articles from this journal, provided due credit be given the PROCEEDINGS

PROCEEDINGS
OF
THE ENGINEERS' CLUB
OF PHILADELPHIA, PA.

ORGANIZED DECEMBER 17, 1877. INCORPORATED JUNE 9, 1892.

NOTE—The Club, as a body, is not responsible for the statements and opinions advanced in its publications.

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Paper No. 1152

"ENGINEERING SOCIETIES AND PUBLICITY"

By C. E. DRAYER, Secretary
of the Cleveland Engineering Society

September 21, 1915

With the birth of science new conditions and new problems came. The intense seeking after technical knowledge in recent years and the great amount of work imposed by discovery after discovery in science, gave rise to an intense specialization among technical men until they have lost in a measure sympathy with the people outside of their own narrow field. While specialization is necessary to scientific progress, there is need that we engineers study the relation of our occupation to the wider interests of mankind. Let us, as it were, break up the crystals of our old ideals, one of which is the time honored precept that our achievements are sufficient witnesses to our ability, and see if the new crystallization does not take on a different form. One crystal may be that advertising and publicity are commendable forms of activity if rightly practiced.

Another condition of modern times is the demand on the part of all people to know about the things which have a far reaching influence on public welfare, on health and industry. So we find at our door an opportunity and a duty to place before the public dependable information about technical subjects.

That the public is interested in the engineer is evidenced by the halo of romance that has been cast about him in literature. It will

be far better for both the engineer and the public when the public learns that in civic affairs the engineer is an honest an efficient servant of the people, capable of taking administrative control.

The implication of the public official, who was a lawyer, that the engineer could not be found with the judicial quality of mind to serve on the Interstate Commerce Commission would doubtless find general support today, for most people picture the engineer drawing hieroglyphic plans according to mysterious rules. He is silent and apart. His language is that blue prints, and the desire of his heart finds expression before the public in terms of earth and metal, inanimate things.

As Berton Braley says of the engineer, "Leather Leggin's" to illustrate his talkativeness.

"When you need to dam a river or to turn it upside down,
  Or to tunnel underneath it in the mud,
Or to bore an' blast a subway through the innards of a town,
  Or to blow aside a mountain with a thud . . .
Why, you call on Leather Leggin's and he does that little thing,
  An' then comes 'round an' asks you 'Is that all?' "

Our position with reference to the public is not unlike that of John Alden courting Priscilla for Miles Standish. Let us speak for ourselves. And let us learn to speak where engineering principles are at issue with such clarity and vigor that in the trial of a case before the jury of public opinion we will get an unanimous verdict. We can.

Our training and habits have not endowed us with eloquent tongues, although the ability to talk well will be added when the awakening spirit impels us to reach up to our opportunities. But a channel by which our story can be favorably told the public lies within easy reach.

Before showing on the screen what use has been made of the public print by the Cleveland Engineering Society and other engineering societies, let us discuss a few of the principles of publicity learned from the experience of several years.

News is a commodity handled by newspapers at a profit. From the standpoint of collecting news, it falls roughly into two classes, that which is gathered by the ordinary reporter or sub-editor at a considerable cost to the paper, and that which is offered gratis. The latter is highly competitive in itself in the cosmopolitan paper for the quantity offered is always in excess of space available.

From the standpoint of the time element, timeliness it is called, news is divided into that which must be released immediately, or on some certain day, and that which can be timed for release. To illustrate: A plate girder 131 ft. 9 in. long, perhaps the longest ever manufactured, passed through Cleveland, Friday noon, and is news Saturday morning and history Saturday noon. But a novel method of handling dirt from excavation was being worked out over several weeks and was for release at the option of the engineers.

One of our editors once said, "I can no more keep the news as it comes from passing through its natural channel, this paper, than I could stop a river by building a dam."

Material offered the papers should be on the basis of news value alone, measured by the standard of the particular paper. Whatever may be our opinions of this or that paper, it must be remembered that the paper with a large circulation is a gauge of the mental character of a large percentage of the people. Before a newspaper can undertake to educate the public, it must have a circulation, and circulation depends on the appeal of its news columns. Hence it is easy to see why newspapers are not reformers nor much in advance of the average reader whose education and standards are very much below that of the college bred engineer.

Authority and authenticity are attributes of a paper correlative with popularity. Hence it is that the reporter feels impelled to quote when opinions are given, and that the editor is anxious to have articles setting forth new principles signed by someone competent to speak. Of course, to quote authority relieves the paper of responsibility, which may be of importance on such burning questions as prohibition, woman's suffrage, or who started the war. If time permitted we could go into a statement of the broad principles of newspaper making in greater detail, but how to write and place copy must be given consideration.

To write and place copy which is competitive with other copy in its class is a problem in salesmanship to which the principles of that calling apply. The principles of psychology underlying work of this character are now formulated and generally used in influencing men in the commercial field. One of the fundamental principles of salesmanship is acquaintance with the men who are to pass on the material offered. This principle was unconsciously applied by a successful contractor, who said he never read the specifications, but got acquainted with the chief engineer.

The editors at the head of the several departments, real estate, railroad, finance, marine, Sunday, each has different needs which vary somewhat with each paper. For instance, the real estate editor on one paper was also movie editor, and the railroad editor of another wrote Sunday copy on minor theatricals. Gradually the special needs of the several departments may be learned and material supplied accordingly. To illustrate, the railroad editor has Sunday off, yet the Monday column must be filled. That is, on Saturday he must do two days' work for Sunday and Monday. News that can be held for Monday will be invariably welcomed by him.

When we started publicity work, we interviewed the managing editor of one of the papers who was an acquaintance. We then learned by going to the editor before putting ideas into writing not only was his viewpoint obtained, but after he had approved its central idea the copy was in a way to succeed ever against scarcehead competition.

When one article is handed in it is well to have the idea of another or two to submit for opinion and thus avoid the noticed effort to see a busy editor, or the chagrin of an unsuccessful call.

Study the style of the papers. To get the style, let the writer clip a few articles that seem especially good and have them before him while he prepares his copy until the style comes. Get a good first sentence or "lead" to attract attention and guide the reader into the story. Particularly in advance notices aim to answer the questions what, when, where, in the first sentence. Writing of headlines may best be left to the practiced newspaper man.

It would be much better to have nothing in the paper because of inability to prepare copy suitably than to have it refused. Lots of material is offered to the papers in form unsuitable for publication and, unless it possesses unusual news value, it goes into the waste-basket.

All copy should be typewritten and clear for time is a vital element in getting out a paper.

To summarize, the successful preparation and placing of copy depends upon three things: (1) news merit, (2) acquaintance with the editorial staff, (3) an understanding of the problems of newspaper making.

Now to find the man with a "nose for news." The ability to pen expressions that fit the average mind will come with practice and a study of psychology, just as the ability to design comes with practice

and a knowledge of the laws of mechanics. Of course, aptitude varies in one as in the other, but what is essential is an abundance of faith in the cause, a spirt of propaganda that will not be daunted.

There are certain definite perquisites of publicity which accrue to those undertaking the work. Perhaps most valuable of these to the

FIG. 1

individual is the opportunity to become acquainted with the leaders in the profession and to become a dynamic force among one's associates and in the community. The call of your society is for those able to do useful work for it and to forward the principles for which it stands.

Another advantage to those who tell about what others are doing is found in the broadening of the knowledge of him who tells the story, for to write about a technical subject so that it interests the least educated as well as the most educated in the community requires that there be no haziness in the mind of the writer.

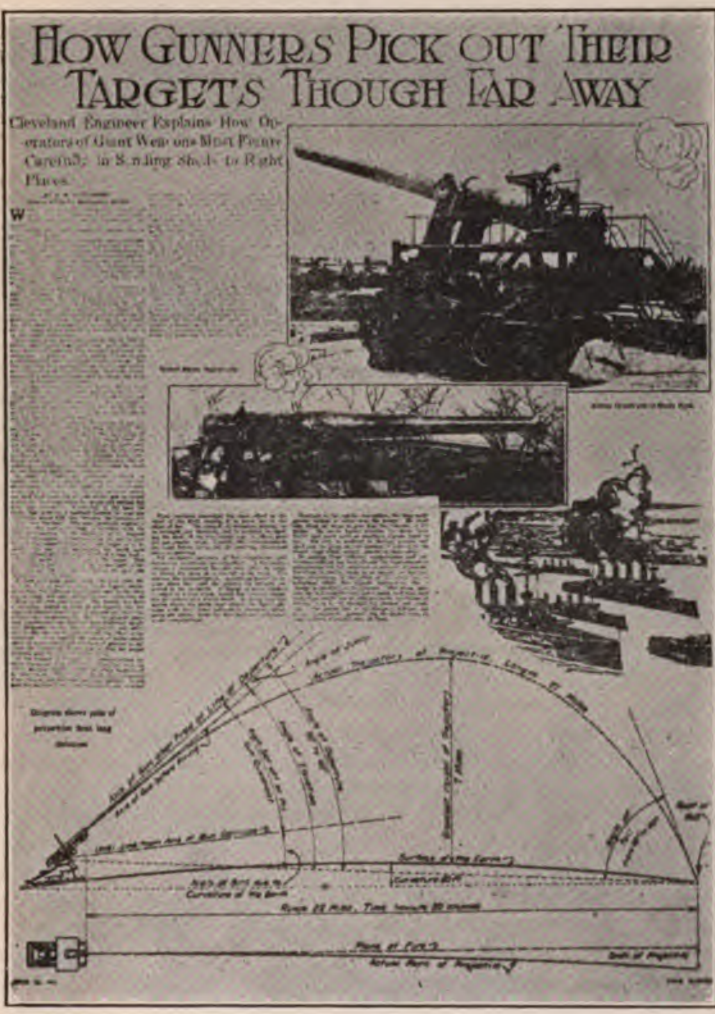
To the man who is looking forward and not back, who has the spirit of service to those in the profession and to the entire community, here is an opportunity of wonderful possibilities.

Fig. 1. This slide is made up principally of clippings telling about the civic activities of the engineering society.

"Big Stick Shown in Building Code." "Swat Building Code." Cleveland has been struggling lately with the revision of the building code. The actual work of revision was done by a joint committee composed of the Chairman of the Building Code Committees of the Cleveland Engineering Society, Builders Exchange, and the Cleveland Chapter of the American Institute of Architects. The code has been carefully studied by the committee and some 460 sections have been revised and 260 new sections added, the City Council turning into law what the committee approved. It has been a Herculean task to which these men gave unselfishly of their time without renumeration of any kind.

FIG. 2

"Experts Sought to Aid in Testing City Employees." "Plan Exam for City Engineering Force." The Civil Service Commission asked the society to assist it by taking charge of the preparation and mark-



HOW GUNNERS PICK OUT THEIR TARGETS THOUGH FAR AWAY

Cleveland Engineer Explains How Operators of Giant Weapons Must Figure Carefully in Sending Shells to Right Places

FIG. 3

ing of papers for engineering positions. Results to both the society and the Commission have been very gratifying. The Commission secured the services of experts at no cost to the city, whereas during

the previous year it had paid some $900 for examination of candidates for engineering positions, yet complaints had been made that proper relative weights had not been given to experience and theoret-

WHY NO BOAT CAN WITHSTAND A TORPEDO

Only Protection Against Such Disasters as Befell Titanic and Lusitania is Prevention of Collision or Attack, Engineer Shows.

The Whyfor of That Extra Hour of Darkness in the Morning

FIG. 4

ical training. The Secretary of the Commission told us that candidate were satisfied after the engineering society took charge.

In this case our Publicity Committee tipped off the reporters and they dug up their own stories from the Commission.

"Praise Tech Work, but Point out Faults." "Vocational Guide Urged for Pupils." This was our first publicity work, in August of 1912, and is an abstract of the report of the Committee on Technical Education of the Society after it had studied Cleveland's technical schools.

FIG. 5

"Civic Clubs Unite to Pick Boys Jobs." Reports a joint meeting of the Engineering Society, Y. M. C. A. and Chamber of Commerce to discuss vocational guidance.

"Want Committee for Crossing Plan." The Bri
Crossing Committees of the society found little h
planning the work of grade elimination in the city
manner and recommended that future work be ar
general comprehensive scheme.

"Yale Man to Talk Smoke" and other clippings are devoted principally to arousing public sentiment against unnecessary smoke and to induce as many as possible to attend a popular lecture on "How to Burn Soft Coal Economically and Without Smoke," delivered by Dr. Breckenridge at a joint meeting between the Chamber of Commerce and the Engineering Society. The two clippings on the right are the reports of the meeting, which was attended by 600 engineers, manufacturers and citizens. The editorial in the lower left corner

Fig. 6

of this section was suggested to one of the papers after the editor's attention had been called to the annual report of the Smoke Inspector, a member of our society. The report was abstracted and recast in newspaper style in a three-quarter column article, not included on the slide.

Fig. 2. This slide pictures publicity obtained in connection with our last two annual dinners and shows our first feature article. The pictures, "art," as newspaper men call it, at the center of the screen

are of Esselstyn, President of the Detroit Engineering Society; Bell, President of the Engineer's Society of Buffalo; Stucki, President of the Engineer's Society of Western Pennsylvania, and the outgoing and incoming presidents of the Cleveland Engineering Society. "Engineers Vote to Aid Scholars" and "Engineers May Raise Fund to Aid Students," were in the morning papers following the dinner.

FIG. 7

There were two reasons why space was small in [illegible]ning papers. One was the late hour at which the banquete [illegible]llowing short time to get copy in before the last [illegible] went to press. The other reason was that [illegible]rately —to the society, I mean—resigned a[illegible] day of the dinner, taking all of the first [illegible]ling

ones besides exciting the reporters. The pictures of the three men in the lower left center were in the advance notice of our dinner last year.

The aeroplane article is our first feature article and appeared in a Sunday magazine section. In the lower left hand corner is the advance notice of the meeting, consisting of a picture of the speaker and some 100 words telling about him and what he was to talk about.

When we went to the Sunday editor and asked him if he'd like a feature article on flying machines, he said, "Yes, only you engineers are too technical." We told him we were interested mainly in know-

FIG. 8

ing whether he was receptive to the idea and that he didn't need to print the article if it didn't suit him. "That's a go," he said.

The Chairman of the Publicity Committee has been seeking the right sort of an assistant for a long time. When he found a young man ready to attempt the preparation of this article under his direction, he felt about the young man as the editor did toward the article—he might come through, but past evidence was to the contrary. The article was blocked out. The writer came back with a sophomoric composition, a good undergraduate essay. We went over it in detail and he rewrote it, improving it considerably and approach-

ing newspaper style. Again it was given back to him to rewrite. He did it all over the third time and never flinched. The editor was highly pleased. Now both our Sunday papers are eager for our feature copy and one article has been paid for. Pay had been offered us previously, but we then told the editor the material was not for sale. The effect this statement produced upon him was worth the sacrifice in money.

Fig. 3. "How Gunners Pick their Target Though Far Away." We stated before that any plan for publicity by engineers must be based on a systematic scheme to educate the public. From the standpoint of the engineer, the public includes the men who make the newspapers.

The article on the screen might just as well have been captioned "Long Range Trajectories." Had we attempted such an article in the early stages of our publicity work, the editor would have been inclined to view the attempt as too technical. Indeed, a good many engineers would be prone to say that the subjects of trajectories and ballistics are too involved to be understood by the average reader of the daily newspaper. After the article was published and opinions expressed as to its value, the Sunday editor wrote us, characterizing the article as a "knockout' and asking if we couldn't write him another soon.

While no positive statements are made in the article, whether the Germans, with reasonable care, could have avoided the destruction of historic and sacred edifices in the cities they were bombarding with cannon located 20 miles away, no great acumen is required of the reader to judge correctly.

The editors of both papers have expressed appreciation of the line drawings to make the text clear. We furnished text and diagram while the newspaper furnished the "filling in" with pictures and sketches.

Fig 4. "Why no Boat Can Withstand a Torpedo." This article is devoted to an explanation of the principles of buoyancy governing the design of ships. By picturing the difficulties an urchin meets in trying to keep a floating tomato can upright until he discerns that he must put some stones in the can, very technical terms like center of gravity, center of buoyancy and metacenter can be i[illegible] ith-out frightening the non-technical reader. Even a [illegible] ne to us and told us that he enjoyed the article an[illegible] l things from reading it.

Touching upon the point of timeliness of news, this article was cast for the presses when the Eastland capsized. One of the editors accused us of being accessories before the fact. In defense we would say had the Eastland turned over a week earlier, the caption would doubtless have been different. In this article, as in the gun pointing one, we furnished the text and diagram, the paper the "filling in." It was syndicated by the paper that published it, but no division of receipts was made with the publicity committee. We are going to try a little syndicating of our own in the no distant future.

"The Whyfor of that Extra Hour of Darkness in the Morning." For several years a few misguided reformers in Cleveland crusaded to have the city adopt Eastern instead of Central Standard time. The argument is based on the statement that by Eastern time we would go to work an hour earlier and have an hour more for outdoor recreation in the afternoon. The writer took this method of setting before the public the relation of daylight to darkness throughout the year and endeavored to show that one time is as good as another for the measure of the 24 hours, but that the vital thing is to arrange working hours so as to use daylight most economically. The article was prompted by the feeling that it was a duty to set before the people information which he, as a technical man possessed, in order that judgment might be based on fact.

Fig. 5. "How a Railroad Was Saved From Burial." The ability to meet new conditions with new methods is an ordinary attribute of the engineer. This article describes how a railroad engineer stopped an earth slide by blowing up into a barrier the soapstone on which the superincumbent earth was slipping. The feat was performed on a railroad connecting Cleveland and Pittsburgh, hence had local color common to both cities. The story, as published in a Pittsburgh paper, also appears on the screen, and was furnished by the Engineers' Society of Western Pennsylvania.

With the local story as a "news peg," several earth movements of interest were reviewed, some that had happened several years ago, and which had been written up in the newspapers at the time. It may be truthfully inferred that ancient history may be made into news.

Fig. 6. "Cleveland Engineers for Peace." The Good Will number of the Journal of the Society is an argument for universal peace, but makes no reference to the present cataclysm in Europe. It is based on the idea that modern war is a mathematically scientific

game, played with deadly machines evolved by the engineer. With the same scientific principles in mind, if the efforts spent in war were turned to the work of peace—in peaceful rivalry instead of destruction—a tremendous advance in human welfare would be the result. The Publicity Committee sent copies of the Good Will Journal over the country, wrote reviews of it for periodicals and distributed several hundred copies to citizens of Cleveland, and placed them in downtown offices of physicians and dentists, libraries and the like, where they would be read by many people. The review appearing on the screen, is published verbatim as the committee prepared it.

"Engineers are the Men who make Dreams Real." This article was suggested by the publicity committee to one of the sub-editors who was charged with writing an interesting story for each Sunday. Naturally the most difficult part of his task was to find a subject and material. We arranged for an interview with an engineer who could talk in an interesting manner to a reporter. The definition of "engineer" the newspaper evolved is rather apt. "An engineer is a man who somehow, some way, tames the forces of nature, helped by science, and makes them do man's bidding."

"Electrified Railroads Bound to Come in Time." At a time when the electrification of railroads entering Cleveland was being agitated, the engineering society invited N. M. Storer, of the Westinghouse Electric & Manufacturing Company, to lecture on the subject. The meeting was held at Case School and was attended by several of the city officials. The clippings on the screen are the advance notice and abstract of the lecture appearing on the Sunday following.

"Engineers See Wonders of the Press Plant." On Tuesday evening, our regular meeting night, we had three newspaper men tell us about the making of a newspaper. One spoke from the standpoint of the editor, a second about the business and advertising end, and a third, a member of our society, gave the principal address which was devoted to the power presses and other machinery of a newspaper plant.

On the following Saturday afternoon we visited the largest three plants in the city, each within a few minutes' walk of the others. The Press took our pictures just after we had started th[illegible] building and in forty-two minutes had the paper print[illegible] hand to us as we left.

"U. S. Engineer Speaks Friday." Of the two talks mentioned in this notice, the efforts of the Publicity Committee were directed to making the one at Epworth Memorial Church on Sunday night a success. We had notices posted on the bulletin boards of various civic organizations and had announcements made where practicable. We were gratified to see an attendance of several hundred on an especially inclement Sunday night.

"Engineers to See Pittsburgh Plants." A very pleasant and profitable custom of visiting back and forth has grown up between the engineering societies of our section. We have visited the Engineering Society of Pittsburgh, Buffalo and Detroit, and plan a trip to Toledo. The Detroit engineers on September 11th returned our visit of last Spring.

I am inclined to place greater value on the social and good fellowship part of these programs than on the professional benefit gained from visiting plants in other cities, large as that may be. Trips by boat are effective in getting members acquainted with each other, out of which grows a common interest.

The picture in the upper right hand corner was part of an advance notice of a popular lecture in East Technical High School by E. E. F. Creighton, Consulting Engineer of the General Electric Company. When we gave a duplicate of this picture to one of the papers, the city editor said it wouldn't justify reproduction. He said it was too black. When we showed the picture to the competing paper, we mentioned diplomatically that the editor of the other paper was afraid there wasn't enough contrast. The editor being addressed said, "Let us try it." The graphicness of the notice without the picture needs no comment.

On the right hand of the screen "Yale Summons Local Engineer" is a notice that one of our distinguished members was to give his lecture on "Engineering of Men" at Yale. Below that is an item informing the public that former Senator Burton has given his library of river and harbor literature to the local society. Next is an item telling of an event in our chess club when seventeen of its members were pitted at one time against a well known champion. At the bottom of this column, "Cable Long Used Bears 300 Tons," is an account sent to us by one of our advertisers in the Journal. It is a legitimate news item and good publicity for our advertisers and properly falls in the scope of our Publicity Committee's work.

"Bridge Foundations a Mighty Problem" properly may be classified as service to the community. The building of the foundations of a great high-level bridge, the main artery between two parts of the city, gave rise to a lively controversy as to their safety. The public had a right to know the truth. The county bridge engineer was asked to read a paper before the society describing the foundations, his paper was abstracted with technicalities omitted or so worded as to be understood by the reader of average education, and published in one of the papers on the Sunday following the meeting.

"Producer Gas to Eliminate Smoke and Save Fuel." Here are shown advance notice of the meeting and an abstract of Dr. Fernald's paper as it appeared on the Sunday following the meeting. Dr. Fernald was pilot of the Cleveland Engineering Society when its course was changed from a jack-in-the-box mutual admiration society to the wide-awake civic and professional organization we have to-day.

Fig. 7. "Local Men Will be Prominent in A. R. E. A. Meeting" and most of the other clippings in the upper left quarter of the screen appeared in the section of our papers devoted to railroads. The longest article is signed by the railroad editor, and the text is verbatim as we prepared it. "Railroad Engineers Conclude Convention," was a telegraphic report sent from Chicago, press rates collect, to the Cleveland papers after one of the railroad editors had suggested that we do it.

"May be Chief Engineer of Alaska Railroads." When Hunter McDonald, then President of the A. S. C. E., was being mentioned as possible head of the construction forces for the Government's Alaskan railroad, an excellent "news peg" was at hand on which to hang quite a story about the A. R. E. A. and A. S. C. E.

"Favors Unit Plan of Concrete Work." Here again are shown advance notices appearing on Monday preceding the meeting and a write-up of the lecture appearing on the Sunday following. The section of the Sunday paper in which this story appeared went to press on Friday night. In this instance copy was handled by the real estate editor who was also movie editor, although the dutie either job would keep one man comfortably busy. Copy, pres recent development in building construction eased the labor real estate editor and was given a hearty welcome by him.

"Weather Prophet's Secrets Disclosed."

"Weather Mixer Joins Engineers." Shortly after the new weather forecaster took up his work in Cleveland, he became a member of the Engineering Society. It was quite proper that both the man and his lecture on the "U. S. Weather Bureau and its Work" should be given some publicity, introducing him to the community. Cleveland is in a district subject to so many and sudden changes of weather that the lot of the weather man is a precarious one and at best many of our worthy citizens would greet him with a hatchet.

The two clippings to the upper left in this group are the advance notices. When we came to write the one which is straight reading matter, we got down our cyclopedia and discovered some interesting things, one of which was that a Clevelander while in Congress had a hand in the formation of the Weather Bureau. This, and several other interesting points, were ancient history, unless there could be found a "news peg" to hang them on, that is, to justify them. The new weather man and his lecture was the peg.

Fig. 8. "Engineering as a Life Work." Early in our publicity work there was published in one of the local papers a letter from a young man to the editor asking what the opportunities are in civil and mechanical engineering. The editor printed below the letter a request that engineers of each of these branches answer the question. Of course, we are amused that anyone should expect the editor of a daily paper to answer the question, but the asking indicates at once the opportunity to perform public service through the medium of the daily papers.

Here was an opportunity for the Publicity Committee. It accordingly asked the President of the Society to prepare an article in answer to the question to be offered to the editor of one of our papers. The editor liked the idea so well that he called for more and the series grew until there were fourteen articles. These articles with a few on the branches not treated in the Cleveland series have just appeared in book form with the title, "Engineering as a Career."

In any local engineering society there are men pre-eminently qualified to tell the young man what the opportunities are in the engineering profession and what is required in the way of training to succeed. Thousands of youths, their guardians and parents would eagerly welcome such advice, but they don't know how or where to get it. We are of the opinion that such a series as was run in Cleveland could be written in your society and that the papers would gladly

share in the opportunity to place such dependable information before the community.

There are several ways that may be used by engineers to educate the public besides the public press where an unsympathetic editor may inhibit our efforts. The Engineers' Society of Pennsylvania has conducted Industrial Welfare and Efficiency Conferences to the evident satisfaction of all participants.

As soon as time permits we plan in Cleveland to enlist a few of our younger engineers to give illustrated lectures on engineering subjects before small gatherings in churches, schools, libraries and the like. It is hoped that a sympathetic understanding of engineering knowledge and skill can be brought about more quickly by a personal contact of this sort. In addition, the speakers will gradually acquire by practice that facility of expressing on their feet which is necessary in order that we may argue on equal footing subjects in dispute before legislative bodies or large gatherings of citizens.

It is evident that the first missionary work must be done among engineers and that the measure of our progress in civic activities will be determined largely by our working together not only in communities but everywhere. In a word, Engineering Co-operation.

The experience which has been gained in one society should not only be the common property of all, but the peculiar conditions existing in each place should be interpreted so that general principles may be formulated. For instance, in Philadelphia the local sections of national societies are affiliated with the local society. In Detroit the quarters of the Engineering Society are rented to local sections, but coordination of effort is still to be worked out. In Cleveland the formation of sections of the national societies does not come about because it is felt that the local society so well fills the field that there is little need for the local section. Here are suggested the large questions:

Can the interests of the national societies be best forwarded by having local sections in affiliation with or separate from the local society; and, on the part of the local societies, do local sections of the national societies tend to strengthen or disintegrate the local organization? I incline to the opinion that interest in the local society is the parent of prosperity in the national organization.

It seems apparent that the interests of all engineers and techni men have so many points in common—dovetail, as it were—th any community there should be one home for all and that alon

tain lines all shoulders should be to the wheel for the best interest of the community and the engineering profession.

It can be truthfully said that legislation has often failed to take the constructive form favorable to public interest, and largely because the engineer has not taken his just responsibility as a citizen. To what extent should we enter politics? It might be rashness to enter actively in political campaigns as yet, for the stage is not properly set nor are the actors trained to reach the audience in public debate. But in matters of pending legislation, the lawmakers are ready to listen to what engineers say. In Cleveland the present Mayor would, I venture, not think of appointing a committee of citizens where engineering principles are under consideration without selecting a due proportion of engineers, and that after asking for nominations by the Board of the Society. Our recently appointed City Plan Commission is headed by a member of our Society.

Licensing of engineers by States is advocated in many quarters, by engineers as well as by the public. This is a subject for consideration in a broad-minded and unselfish way.

DISCUSSION

Mr. J. C. Trautwine, Jr. (assuming the chair): Gentlemen, one of the unfailing cures for insomnia is to have the Speaker read his paper from his notes, and I regret to say that my faith in this cure has been shaken this evening. Not only have I missed the refreshment from the evening nap to which I always look forward confidently but I am afraid that I am as wide awake as ever. I shall certainly hope to enjoy the discussion which I have no doubt will be voluminous.

Professor R. H. Fernald: Having been connected with the Cleveland Engineering Society for many years, I naturally feel a very keen interest in the paper of the evening. Mr. Drayer has not made it clear, I think, that he personally is really the backbone of the publicity work of the Cleveland Engineering Society, having been responsible for practically all the material that we have seen on the screen to-night. The Cleveland Engineering Society and engineering societies as a whole owe a great deal to Mr. Drayer for what he has accomplished in this direction.

An incidental illustration of the wide field which has been covered by the publicity work of the Cleveland Engineering Society is shown by the fact that only last night I happened to pick up a paper that comes to my

home, known as Cleveland Town Topics. It is not exactly like New York Town Topics but is a paper of that general type. In glancing at this paper to see what was going on among Cleveland friends, my attention was attracted by an article of considerable length relating to the activities of the Cleveland Engineering Society together with photographs relating to the recent entertainment of the Detroit Engineering Society by the Cleveland Society. One of the photographs showed the Presidents of the two societies and the other the visiting groups at one of the steel plants. I cite this instance simply to show the extent of the field that may be covered and that seems to be of real interest to the public. Such publicity is not only a benefit to the organization itself, but to the city as a whole.

As Mr. Drayer told us, practically every important engineering project that comes up in the city of Cleveland as a city proposition is given careful consideration by the Cleveland Engineering Society at the request of the Mayor. The co-operation of this organization in such matters is frequently requested and the Society is often asked to name experts for making necessary investigations.

I remember very well one question that came up a few years ago, namely, the proper purification of the water supply of Cleveland. Several scare heads came out in the papers to the effect that when the Spring floods came on hundreds or perhaps thousands of people would die from typhoid fever. A filtration plant was called for at an enormous expense. The Mayor requested the Cleveland Engineering Society to advise him regarding this matter. The Society advised looking into this problem thoroughly before spending the millions of dollars called for by the alarmists. The Committee of the Society recommended to the Mayor that before any radical steps were taken, he secure the best experts to be found in the United States for a careful investigation of this matter and that he act according to the report of these experts. This advice was followed and it was found that a comparatively small expenditure of money was required to guarantee the city a satisfactory and safe water supply. The typhoid scare proved to be a bugaboo and the city was saved the unnecessary expenditure of several millions of dollars. This is simply an illustration of the work of a public character that has been done by the Cleveland Engineering Society.

Mr. Trautwine: I gather from what Prof. Fernald says that Mr. Drayer does not practice what he preaches. "John, why don't you speak for yourself, John." Evidently that important duty has been overlooked by Mr. Drayer.

Mr. W. Copeland Furber: I have been very much interested in this presentation to-night and I could not help contrasting in my mind the great success the Cleveland Society has had with the very poor success—or lack of success that The Engineers' Club has had in getting engineering matters before the public. It is often ver difficult to determine just what the editor wants, or what he wi

pass, and I think the speaker of the evening has shown that he knows how to do it, and has let a little light in on the method.

My experience with reporters—particularly in Philadelphia—and I hope there is no newspaper reporter here—is that they are young men who have not had the training, either in reporting or in technical matters, that qualifies them to properly report a meeting. I have sat behind reporters at the meetings here in the American Academy of Political and Social Science, and out of a group of six or seven there are probably only one or two who seem to be able to get the sense of the meeting, the others putting in their time drawing diagrams and geometrical figures and other things on their note books. Consequently, when the meeting is reported the report is not only inaccurate but frequently it is very erroneously reported.

I contrasted the methods that I have observed here with those in Washington. Some time ago I attended one of the city planning conferences in Washington and the Washington papers had sent two competent reporters and as the proceedings developed I noticed that they furnished copy to messengers, and a couple of hours after the meeting adjourned I saw a very complete and satisfactory report of the meetings in the papers.

Now, of course, the Washington papers evidently thought that was of great news value and took the time and trouble to report it properly, but I have never seen that done in Philadelphia. I think the answer is that, particularly regarding this club, there has never been any attempt made to furnish the copy to the editors of newspapers so that the reporters can handle it. I think if we should take some of the suggestions from the speaker of the evening that it will be of great help to us in our publicity campaigns.

Mr. Trautwine: I think that Mr. Furber is quite right—that the thing that stood out most pre-eminently to us here at The Engineers' Club was the startling contrast between Cleveland and Philadelphia in respect to the matter to which the speaker referred. I have the honor to be a member of the Public Relations Committee of this Club, and I regret to say that we have done very little. I am at least partly responsible for what it has not done. When we have had meetings and have discussed matters relating to the public affairs we have met with the caution that we must be careful not to interfere with politics—we would be pulling somebody's chestnuts out of the fire.

Mr. Morris L. Cooke: I was not fortunate enough to be here in time to hear Mr. Drayer. I am happy to say that I am fairly familiar with some of the things he has done, and I consider it not only an honor to the Club but a real service to Philadelphia to have Mr. Drayer come here and bring this gospel. Even though I had to spend a part of the evening elsewhere, I felt that I must get here before the meeting was over.

In studying the things that Mr. Drayer has been doing in Cleveland. we must recognize the fact that news has a technical quality, because

without that acknowledgment such a thing as publicity, or as I would like to call it, "advertising," does not exist.

As a newspaper man and, more recently, as a public official, I have found out that an item which may be news Sunday afternoon is not necessarily news Monday afternoon, and each piece of news is valued not only for its own characteristics or qualities, but for its relation to concurrent events. For instance, last Sunday morning I released a story that ordinarily would have been carried in all the newspapers. As a matter of fact it found its way into only one. I mention this as an example of conditional values; and the conditions that caused that story to be turned down were just as easily analyzed as the conditions surrounding the building of a bridge or anything else we call engineering.

The gentleman who was talking as I came into the room spoke of the inferior quality—he didn't mean it just that way—but referred rather to the incapacity of the average reporter to accurately report engineering matters. This is no indictment of reporters as a class, because those of us who have attended engineering conferences in our own line have found that there were many things discussed that we would have had considerable difficulty in properly reporting. If we engineers are going to profit by the example that Cleveland has set us, we must recognize that limitation of these men; we must consider that the average newspaper reporter is paid for his ability to go to a gathering of medical men one night, a night or two later to a meeting of illuminating engineers, and then a few nights later to report a sewage disposal discussion.

Now the point that has impressed me the most is that there are certain classes of engineering matters that seem to me to be absolutely dependent for their development upon advertising, and they are not all of them municipal engineering matters. Naturally, we municipal employees are servants of the people and are doing their engineering work. In municipal work publicity is more important perhaps than it is in private work, but I am sure that even in private work there are certain classes of engineering that either cannot be carried on at all, or cannot be carried on advantageously, except as you proceed with a certain amount of publicity. Such a matter is that of street cleaning. You can pick the five engineers in this club who are best qualified to make a report on a proper policy for cleaning the streets of Philadelphia, but unless you couple with any plan they decide upon, some means by which it may be given publicity and gradually put into execution you might just as well throw it into the waste basket. No matter how efficient a plan you may devise for cleaning the streets of Philadelphia, you would discover the morning after you had introduced it that 80 per cent. of your effort was lost unless you introduced into it the feature of publicity.

When we came into office, for instance, we found that we had approximately 350,000 houses from which we gathered ashes. I do not think I am exaggerating when I say that in 200,000 of those houses there was no receptacle for ashes that, from an engineering standpoint, could be

called a receptacle. The nearest apology was a newspaper, or a strawberry box, or probably a series of strawberry boxes or peach baskets, in some cases lined with newspapers, and in other cases not lined at all. On up the scale there were a few people—I won't mention any names but there were a few exceptional souls who actually had a metal ash can with a cover. Now, of course, that is what we are working towards. It is far off, and it is a long journey, but one of the first steps—someone said there were no reporters here—was to "steal" 50,000 peach baskets in one week. For this, of course, we were liable to arrest. Those ash-filled peach baskets did not belong to the city. But as a matter of fact they are somewhere along the marshes of Philadelphia now and we have 50,000 less peach baskets in use. We have found that in most cases wooden boxes have taken their place.

We tried the experiment in parts of the city of putting one galvanized can on a block, and it was remarkable to see how first the next door neighbor and then the next followed suit. We have had some cases where all the housekeepers in an entire block secured the tin receptacles because it had become a question of social standing. The housekeeper says, "Mrs. So-and-So has a tin can, and if she has one we have to have one," and if one householder puts a top on, then the rest of the tops come.

In some instances we have made moves that we knew beforehand were going to get us in trouble, changes which we knew would bring down on us correspondence and kicks of one kind or another. By giving two or three months' notice, however, and by putting a little interesting statement in the newspapers that such a thing was going to be done, and following it up with letters to the Business Men's Associations and to a few women who were active in such matters, the blow was softened, and, as the expression goes, we have "gotten away with it."

Now street cleaning is only one of a great number of such problems. Any large public improvement can be pushed ahead if you can think of some scheme by which you can visualize it to the people. The best example of that kind that I know of is the main sewer, on which Philadelphia has been working for fifteen years, draining the low section at Broad and Allegheny Avenue. The city was given appropriations every year of $15,000, $20,000—I think the last was $40,000. But we needed $200,000 or $300,000 to finish it, and when the Business Men's Association came to me and asked me whether there was something that could be done I frankly told them that the best we could expect would be $40,000.

As luck would have it, there was present a little German baker woman; she was only about five feet high, with a shawl on and no hat. After his Honor, the Mayor, had listened to the citizens' eloquent appeals for the sewer, this little short baker woman told a painful story of how she lost a barrel of flour every time it rained. This woman's plight had the reporters almost in tears, and her story appeared on the front pages of the afternoon papers. The result was that the people simply tumbled over themselves to give us that $200,000 and when we found that that

would not be enough to complete the sewer, we obtained more. That German woman absolutely deserves the credit for the completion of a sewer which will save this city thousands of dollars every year.

From now on, when I want to get something done, I am not going to get down and pray that somebody is going to build it right and do it economically, but I will be on my knees first as to how to make the people understand it. Because, when they once understand the thing there is nothing that can stand between them and its execution. Experiences similar to that of Philadelphia, results of this same policy, are reported from all parts of the country.

Just one more thought in closing. I think one of the things that keeps engineers from adopting this policy of publicity is not so much the fear that we are going to get into the newspapers—I guess most of us are thick-skinned enough to stand for that—but the fear that we will get in the newspapers in such a way that we seem to say something that we did not quite say. I have been in office for three years and four months. I made up my mind when I went in that I would at least write a letter to every paper that misquoted me. I have written two such letters, and they were about such trivial matters that had I given them careful consideration, even they probably would not have been written. My experience in the last four years shows me that if you co-operate with the newspapers in the way that Mr. Drayer has asked us to do and put yourself to some little inconvenience to prepare the material for them, not in the way you want it but in the way they want it, that your factor of safety of being correctly quoted is about as high as the factor of anything else in this world.

I want to say to Mr. Drayer that I appreciate very much his coming here, and I think it will do us a lot of good.

Mr. Frank L. Neall: In regard to publicity, as related in the paper, I admit the assertion, but so far as knowing anything about engineering, I certainly respectfully admit my absolute ignorance. I was interested in what Mr. Cook said in reference to getting in touch with the papers and assume, to begin with, that they want to know what you want them to know—if you know what that is. In other words, they are anxious to make a good report, but you are stuffed full of the situation and the gentleman that comes to you has probably been following up a first-class murder trial, or some court work, or some entirely different proposition, and if the subject that you are interested in lasts for a week you may have five different men on the same subject, so that none of them can get a perfect idea of the situation, but if you will take the pains to put before them a concise statement and give a little explanation of the tec nicalities, I think that they will be very willing to help you along.

This scheme, the latter portion of which I heard explained, I an excellent one to get the engineers in touch with the public and the public feel that the engineer is willing to explain a whole lot to who don't understand the situation, and in that way mutually help mon object along.

Dr. H. M. Chance: I have had no experience in municipal affairs. The aim of the author of the paper appears to be to bring engineers more prominently before the public. It is a subject that engineers, aside from those engaged in municipal work, should consider. The average engineer does not blow his own trumpet. He is apt to be afflicted with modesty and feels his own shortcomings, and when it becomes necessary to go before the public, is doubtful as to the expediency of presenting his work in a way that carries conviction.

The instance that was just referred to in regard to the typhoid scare in the City of Cleveland illustrates the point. Engineers who were asked to advise the city officials apparently refused to assume the responsibility, and advised the city officials to employ some other engineers to investigate and report. Personally I think engineers in the City of Cleveland, who were interested in the problem, should have been willing to assume the responsibility of giving definite advice. We have had a number of similar occurrences right here in Philadelphia. Our club organization, of course, practically takes the stand that it should not give expression to opinions on subjects of public interest excepting under restrictions which make it impossible to get official expression on any subject quickly.

The club in the past has been backward and perhaps diffident in offering its services to the city. I think the club could perhaps increase its activities in that direction. While the city is well supplied with engineering talent in its several departments there are times when the employees of the city would not care to place themselves on record until the time is ripe to take action. One matter I have in mind that must come before the public shortly is sewage disposal. If sewage disposal is a good thing in Philadelphia, the Engineers' Club might do a great deal to place the matter before the public in an intelligent way, to educate the public so that it would be prepared to endorse the project when it became necessary to take action.

Mr. R. H. Fernald: Apparently my former remarks were not quite clear. I happened to be a member of the Executive Committee at the time the Cleveland Engineering Society was asked to investigate the typhoid fever scare and to make recommendations to the Mayor, and I believe we shirked nothing. Naturally we did not say to the Mayor, "Will you please hire one of us"? We were asked to advise regarding the best method of procedure and we recommended that he secure the best possible experts. One of the men selected was already in Cleveland, the second man, it happened, came from outside but was selected because of his recognized standing in this particular field. Our recommendation did not suggest that the Mayor ignore Cleveland engineers and go outside for experts, but we felt it important that the city secure men generally recognized as best qualified for this particular problem. We were not asked to name specifically members of our organization and we felt that in making our recommendation to the Mayor we were rendering the

impartial service which would prove of the greatest benefit to the community.

There is another point that I would like to mention while on my feet, Mr. Chairman. Mr. Furber brought up a point in regard to reporters that interested me and that ties in well with some of the things that Mr. Drayer has already said. It seems to me that in the case of the Cleveland Engineering Society one of the most important points has been to have someone get well acquainted with the editors of the newspapers and to have someone who could put the material in the proper form for popular consumption. Fortunately Mr. Drayer knew the editors and understood how to prepare the material.

Mr. Furber referred to the fact that certain material at Washington conventions seemed to be handled well. I happen to know that one or two Bureaus in Washington employ as publicity men, men who have formerly had newspaper experience. In one case, with which I happen to be familiar, this former newspaper man has given careful consideration to engineering and technical subjects and is able to prepare in a semi-popular form a great deal of technical matter. He is frequently sent to conventions away from Washington to take charge of reporting the engineering and technical features. He prepares and gives out the material to the local reporters for their papers and they look to him as the source for their material. He has reported meetings of this character in Philadelphia and succeeded in getting ample space in the local papers. Because he is a newspaper man he knows how to get to the papers and as he has prepared himself to understand technical material he does this work most satisfactorily.

Although not all reporters may be able to prepare engineering material in a way that is satisfactory to the newspaper editors and the authors, yet it is possible that in the City of Philadelphia or in the Engineers' Club itself there are men who are familiar with handling newspaper work and know the essential details for working up engineering material in the right form. If such is the case, the problem is not a difficult one, and the opportunity for duplicating the excellent publicity work of the Cleveland Engineering Society should receive our attention.

Mr. Trautwine: I think Prof. Fernald, as Mr. Furber and Mr. Neall have stated, the average newspaper reporter is, of course, absolutely unqualified for reporting properly engineering matters. On the other hand, the average engineer knows very little about preparing articles for the newspaper. Now perhaps we could get a newspaper man here and in the course of a short time we could make enough of an engineer of him to put up acceptable stuff and that material written in the right form and placed in the hands of newspaper men would have very much better effect. It occurs to me that Mr. Maignen who is with us tonight, ought to be able to speak on this subject.

Mr. P. A. Maignen: By all means get all the advertising you can the newspapers. Engineering Societies are impersonal and usuall

with matters of public interest! The Editors, therefore, are more or less free to print what is said at our meetings. But, when the "news," however interesting to the general public or however true, have the slightest symptom of a connection with some commercial Enterprise or personal matter, the Editors are shy.

Twice lately, one of the Philadelphia newspapers sent reporters to the speaker in search of information. They were given "news" of public and timely interest. The reporters wrote good reading matter, but somehow or other it did not appear. It must have struck a snag from the "censor," who perhaps thought that the "news" would be of some "benefit" to "some one" and that the advertising department might object!

The line between what is "news" with advertising or "news" without advertising is elastic, and the "censor" sometimes let things go through which are purely advertising matter, and sometimes they are very exclusive.

Give the newspapers plenty of copy, even though it ran the risk of falling into the waste-paper basket.

Mr. Trautwine: They seem to have avoided that in Cleveland. Mr. Drayer, will you close the discussion by telling us how they did it?

Mr. W. C. Furber: May I say something about the activity of the architects among the local Chapter along these lines in Philadelphia? The local Chapter, as you probably know, have undertaken and did undertake the work of Congress Hall and have worked on the reconstruction of Independence Square. All that work has been done along the lines as Mr. Drayer suggests.

A member: I want to add a word, if I may, to what Mr. Furber said about reporters. Some years ago I was in Cleveland at the convention there and I noticed such experts as Mr. Edwin M. Bassett and Mr. W. S. Purdy, of New York, got on the first column of the front page. Some time after we had Mr. Bassett here in Philadelphia, and I myself wrote to the newspapers asking if they would give the proper publicity to what he said, as it had eminent news value for Philadelphia. We got a little squib on one of the inside pages and some months afterward my name came up before the newspaper editors before the reporters and I was criticised because in my asking for publicity of Mr. Bassett I asked that "competent" reporters be sent to handle the meeting, and that letter of mine was passed around among the reporters and they evidently all remembered my name and evidently took it as a slight upon themselves, which was certainly a case of the shoe fitting the man that took it, when I asked that competent reporters be sent to handle Mr. Bassett's remarks. So that my observation of the Philadelphia reporters is that there are very few of them that are stenographers and that doesn't seem to be true of other cities. In Washington the men that I spoke of were newspaper reporters. In Chicago they were newspaper reporters and they were competent stenographers. But at the Mayor's convention here, which was one of the most important conventions, I was right behind the reporters' table, and

I took particular occasion to notice how they reported it. I think there were one or two men that reported that meeting and in the afternoon newspapers they had absolutely erroneous reports of the meeting. It was not until the following morning that the correct report of the meeting was in the newspapers. The erroneous reports were due to the fact that the men who had reported it did not know what the men were talking about and the discussion was not difficult to comprehend.

Mr. Drayer: I was interested in Mr. Trautwine's suggestion that a newspaper man be brought into the Engineer's Club and taught engineering. But why not let the engineer write the story. Get the spirit of propaganda among engineers. You have among your membership not one man, but ten men, who can write interesting newspaper articles, after they have learned how it should be done. Our success in Cleveland was not obtained in one year, but by conscientious and persistent effort extending over three years. Get some of your men who have a future before them, that want something to do. They are in your Society; find them. Let them go at it, one or two, persistently. Get acquainted with the newspaper staff to learn how newspapers are made. The newspapers will gladly co-operate.

In reference to the honesty of newspaper men I will say we have never had a confidence violated. Sometimes material is for release on a certain day. We always mark very plainly the release date in blue pencil, and pencil the date it is for release, and we have never had a violation.

In the matter of admitting advertising, we have done some advertising. For instance, if a member of the society starts in business we put in the paper a picture of him with a little item telling about his undertaking. On the screen tonight an article was shown headed "Unique Method of Reinforced Concrete Construction." It was advertising, but it had news value also, and that is the test to apply to what we offer the newspapers. It must pass on news merit alone. There have been occasions when we were asked to "put something across" that was straight advertising, but we differentiate carefully.

Learn to judge of newspaper men that come before you just as you judge other men. Some are competent, some are not. Ask the reporter a question in regard to some feature of the story you have just given him, and see if he comprehends it. If he does not, give him a statement and ask that it be printed verbatim, and if it is in newspaper style he will be very glad to do it.

I recognize that many of the members here have a correct understanding of the problems of publicity that are before you. The only thing that remains is to get started. I should like to have the opportunity that is here with some of you engineers to promote engineering publicity i- Philadelphia, backed by the Engineers' Club.

Paper No. 1153.

THE ENGINEER AS A WITNESS

HON. JOHN M. PATTERSON
Judge of Common Pleas Court

October 26, 1915

This is an age of enlightenment in which big business and wonderful engineering feats transcend anything that was ever done by those who lived in the past. We may search the pages of history in vain to find where man was able to utilize the forces of nature and to overcome the natural obstacles of land and sea and air, in the manner in which such things are being done to-day.

The future promises even greater achievements. The scientific construction of buildings of all kinds, of elevators, of railroads, of broad highways, of bridges, of canals, of harbors, and of all the other enterprises of modern man, require, not only the skill of the civil engineer in designing and supervising the work; but in case of disputes between parties or in case of accident to those engaged in the work, it is absolutely necessary, at times, to have the trained engineer go upon the witness stand, not only to testify to facts, like the ordinary witness, but also to sometimes give his opinion based upon his experience and training in his chosen profession.

King David once said, "All men are liars." To the inexperienced person who sits in a courtroom and listens to the numerous contradictions between witnesses to the same transaction, the truth of King David's statement seems obvious. As one becomes more familiar with the mental processes of the witnesses, however, it would seem that cases of conscious and wilful perjury are quite rare, but that, as a whole, human testimony, even when intended to be honest, is inaccurate and is frequently worth very little.

The great historian, Freeman, has said: "I am beginning to think that there is not, and never was, any such thing as truth in the world. At least I don't believe that any two people ever give exactly the same account of anything, even when they have seen it with their

own eyes, except when they copy from one another." It was no less a person than Goethe who declared that "the only form of truth is poetry."

King David's denunciation still adheres, by common consent of lawyers, judges and laymen, to the expert witnesses. That the reputation of this class of witnesses for truth and veracity is shockingly bad, is a matter in which there is surprising unanimity.

Mr. Taylor, in his work on evidence (Sec. 58) speaking of them, says:

"Their judgments become so warped by regarding the subject in one point of view that even when conscientiously disposed they are incapable of expressing a candid opinion. Being zealous partisans, their belief becomes synonymous with faith as defined by the apostle, and it is too often but 'the substance of things hoped for, the evidence of things not seen.' "

Mr. Redfield, in his work on "Wills" (Vol. 1, page 103), says:

"Medical experts are beginning to be regarded much in the light of hired advocates, and their testimony is nothing more than a studied argument in favor of the side for which they have been called."

These opinions might be multiplied without number.

Many of the objections to expert testimony are based upon its inherent weakness. They are directed toward defects which exist in all human testimony, and are inseparable from any system of trying differences between man and man, but which afford no sufficient reason for excluding such testimony.

In any litigation the probable truth is all that courts can hope to attain, whether with or without the aid of expert testimony. Absolute justice the courts do not profess to administer; they must and do rely upon human agencies, with all their limitations and imperfections, to arrive at the probable truth; and if expert testimony is more unsatisfactory than others, allowance must be made for the nature of the subject matter and its inherent weakness, and accept it as less harmful to society than the failure of justice which would ensue without it.

The highest and best form of evidence is supposed to be that given by a witness who speaks as to something that he has actually seen heard or observed. But the capacity for observation, for receiv and noting impression, is, in the average person, so limited th can observe and record a part only of incidents hurriedly trans

in the confusion of his presence. After a lapse of time the impressions made on the memory by what one has observed, become indistinct. The powers of memory, then, cannot be safely trusted to discriminate correctly between the sources from which those impressions are derived. Consequently a witness is apt to confuse that which he saw or heard with that which he believes. Then, too, personal bias intervenes and colors, to a greater or less extent the version which the witness is able to give of that which he recalls. These powers of observation and of memory are unequal in different witnesses. They vary at different times, even in the same witness, as his attention may or may not have been fixed, or his opportunities for observation may or may not have been good at the time the events happened about which he is speaking. The result is, that between witnesses who speak from personal knowledge to the same event or transaction, the differences are so great and the conflict often so irreconcilable that the search for truth, even amid the testimony of honest witnesses, may be likened somewhat unto the search for the grain of wheat in the bushel of chaff.

In the domain of expert testimony the inherent difficulties are much greater. Expert witnesses do not speak facts or of their personal knowledge, but give opinions based upon facts to which others testify; it is not surprising, therefore, that their testimony is, as a rule, much less reliable. Expert witnesses are not only subject to the same mental limitations as are laymen, but the subjects as to which they are usually called to testify are more subtle, more difficult of ready comprehension, more complex, more speculative. They are also often called as to matters with respect to which the higher and more reliable forms of testimony cannot be obtained.

Some of the criticism of the expert is due also to the popular misconception that there is always a right and a wrong side to every legal controversy. The truth is that there is seldom a plainly right and a plainly wrong side to a difference of opinion. Persons seldom carry their differences to the stage of litigation where one is plainly right, and the other plainly wrong. But there are a large number of complications arising in the course of business, and in the relations of life which are due to a failure to settle difinitely in advance the exact terms of an agreement—cases in which some important consideration is left open for future adjustment or is not taken into the account; cases in which from one cause or another persons doing business together, fail to understand each other in the same

sense, and the result is a final disagreement as to their respective rights. And here begins the need of the law and the lawyer.

None the less, the boast of the English law is, and has been, that there is no right without a remedy, no wrong without a process to redress it; the law is exceedingly reluctant to say to any supplicant that it has no means whereby the truth or right of an alleged grievance can be got at, and a just decision made. A familiar example will make clear the difficulties in this respect with which imperfect human tribunals are called on to deal.

A husband and his wife, or a father and his child, may, and often are, lost in a shipwreck, or killed in a collision. And it becomes necessary in the distribution of property to determine which died first; if the husband or the father, the estate may go to one set of persons, if the wife, or the child, then to another set of persons. If direct evidence on the subject can be obtained, it has always been given the preference. But, in the early days of English law, rather than admit themselves to be helpless in the face of an entire failure of such proof, the courts resorted to presumptions based on the assumed ability of one person, rather than of another, to resist death; and it is only within comparatively recent years that the courts have been forced to admit that the situation thus created is insoluble by legal means, and that as courts can only grant relief after proof of the necessary facts with legal certainty, the litigant who asks the aid of a court must be denied it, unless he comes armed with the requisite proof. The result often is that the person in possession is permitted to retain the property regardless of what may be the exact rights of the parties.

But the law abhors a result of this sort, and to avoid it in other similar situations, has permitted the use of opinion and expert testimony to what, at times, may seem an unreasonable extent.

In considering the various objections to expert testimony and the suggested remedies, it will aid one in clear thinking to recall just what expert testimony is and when it may be used. "An expert is one instructed by experience, and to become one requires a course of previous habit and practice or of study so as to be familiar with the subject."

Such witnesses may be called whenever the matter of inquiry is such that persons without experience are not likely to be able to form a correct judgment upon it, for the reason that the subjec

matter so far partakes of the nature of a science, art or trade as to require a previous habit or experience or study in order to acquire a knowledge of it. If the question involved lies within the range of common knowledge, expert testimony may not be used. If, on the other hand, the question involved requires special experience or special knowledge, then the opinions of witnesses skilled in the particular science, art or trade to which the questions relate are admissible in evidence. It is not because the witness has a great reputation for sagacity, or sound judgment, or powers of reasoning that his opinion becomes admissible, for if that were so, wise men might be called in all cases to advise the jury, and that would change the mode of trial. The admissibility of an expert's opinion is tested solely by the subject matter and his qualifications.

It cannot be denied that those rules are sound and true. In fact, unless we are to dispense wholly with the system of trial by jury, this sort of testimony is a necessity, for the plain reason that jurymen are selected from the average of mankind and are not required to have any special skill or knowledge in the branch of art, science or trade drawn in question on the trial. Indeed, though trial by jury were abolished, and a bench of Judges were substituted, the necessity for expert testimony would be very slightly diminished, because the questions arising in litigation are so diversified that the most learned Judges would be quite as helpless as an ordinary jury man. Unless, therefore, one is ready to admit that the truth should not be sought from those best able to give it, and that issues of "great pith and moment" shall be decided without receiving all the light reasonably obtainable, no branch of expert testimony can, it seems to me, be safely limited to a scope narrower than that hitherto recognized as legitimate.

The critics of expert testimony seem to act on the belief that the only experts called as witnesses are physicians, surgeons, alienists, toxicologists and specialists in handwriting. Most criticisms, at least, are made in connection with these classes of witnesses. Critics do not take into account the great army of experts who are daily before the courts of the country testifying as to matters of civil engineering, electricity, mechanics, architecture and building, commerce, trade, navigation, stock breeding, manufacturing, insurance, printing, publishing, binding, mining and a dozen other occupations and callings which, at least, in some of their features, involve matters beyond the scope of the ordinary knowledge of the ordinary man.

There are many grounds for criticising the expert and his testimony. Some of these attacks are just, some, I suppose, are unjust.

Many who discuss the question begin by attempting to discredit all, worthy and unworthy alike, who testify as experts. This is just the state of mind desired by the fakir experts and their employers who seek to defeat justice through such testimony, and is a sure means of making it more difficult to get the best men to testify as experts.

Practical improvement certainly is possible, but it is not to be brought about by indiscriminate criticism but by criticism and correction of the procedure that makes possible the prostitution of expert testimony.

The abuses of expert testimony are well known, but some of the causes that have led to the abuse are not always so freely discussed, especially by those who debase expert testimony in order to win law suits. The "contingent fee" has no doubt been a potent means of debasing expert testimony. When an attorney becomes in effect a partner in a controversy, his zeal in gathering testimony is naturally stimulated, and if his success depends mainly upon expert testimony he is inclined to look till he finds just the kind he wants.

The technical expert witness is beset with the same temptation that surrounds every lawyer, that is, the opportunity for hire to defeat the ends of justice. Unfortunately, there are those in both fields for whom the temptation is too strong.

The corrupt expert witness is a willing tool in the hands of a willing attorney. One of these parties is often overlooked and strange to say, the most violent criticism of experts usually comes from those who themselves have prostituted the subject. The zealous attorney may succeed in befogging the subject by the harmful errors of the inexperienced and uninformed, who are urged to undertake to do what no man can perform, or by the use of the witness without conscience who is simply a perjurer for hire.

Zealous advocates can tease, flatter, threaten and bribe specialists to assist in trying to show, not always perhaps that black is white, but that black is at least a light gray.

Much of the discredit that has been brought upon expert testimony has come from members of the medical profession who have been used in this way by zealous attorneys simply as tools to perpetrate fraud. In order to illustrate some of my remarks and to

give point to some of my arguments I shall have to refer, at times, to the medical expert—I mean of course the expert who does not always tell the truth. The medical profession needs to purge itself of this unworthy member.

The giving of expert testimony would be comparatively a simple thing if it only required the scientific investigation of a subject where all are equally desirous of discovering and showing the whole and exact truth. The inexperienced witness is surprised to find that in proportion as his testimony is effective and convincing he may be attacked and perhaps humiliated, and the testimony of a competent and honest man may be rendered almost valueless because of his inexperience as a witness. He does not know his rights, becomes exasperated and confused and is perhaps led into exaggeration and apparent contradiction and leaves the witness stand resolved never again to subject himself to such an ordeal. If such a witness is followed by one brought in simply to confuse the issue by testifying against the facts, it can readily be seen how justice may be defeated.

It is certainly important to consider what can be done to correct or lessen the manifest evil. The first natural answer is, "Do not let liars testify," but here we meet a constitutional obstacle that it may not be possible to overcome. That well established legal principle which allows a man to call his own witnesses will probably make it impossible to keep liars out of courtrooms as witnesses, but it certainly is possible by official designation and judicial recognition to so enforce the testimony of worthy and competent men that the testimony of opposing corrupt or mistaken witnesses is rendered less harmful.

It has been suggested that the hypothetical question should be suppressed or not permitted.

Another eminent authority says he would abolish altogether the use of the hypothetical question on direct-examination. He would require the expert to be present in court during the trial, listen to all the evidence, and at the end of the trial, go on the witness stand, "and give his opinion based upon all the evidence in the case just as it was presented." Then, upon cross-examination, while he would permit the use of the hypothetical question, he would limit it to the facts of the case which must be fairly presented in the question asked. The practice of allowing on cross-examination any kind of a

hypothetical question based on a part of the facts in the case or on assumed facts not in the case he would abolish.

These criticisms are not without great force. But the solution of these difficulties is not easy. The hypothetical question grows out of the institution of trial by jury, and is a part of its warp and woof. The ultimate question of fact in issue must be determined by the jury unless we are to abolish that method of trial and substitute something else. An assumed state of facts in the form of a question for the purpose of allowing the expert to give his opinion, is the effort of the law to preserve the independent right of the jury to decide the issue of fact involved and to give them at the same time the knowledge of an expert in the matters beyond the range of their experience. If the hypothetical question is abolished, and the expert is turned loose to give his opinion on the case as a whole, none of the evils of expert testimony are avoided. He becomes also an expert on the veracity and integrity of the other witnesses. He gives his opinion, not only on the matters beyond the range of the experience of the ordinary man, but on the weight and credit of the testimony, which is peculiarly the right of the jury to pass on. The expert thereby usurps the place of the jury and decides for himself what part of the evidence in the case he believes to be true, what part is material to the formation of an opinion, what part he may see fit to regard or to disregard as not affecting his conclusion. Under the present system, when all the assumed facts forming the basis for an opinion are set forth in the question, it is possible to direct the jury's attention to those facts which are not fully proved or as to which the evidence conflicts, and to substitute another theory which other evidence tends to prove and thereby modify or control the conclusions reached by the expert. To abolish the hypothetical question, is, it seems to me, but a halfway step to the substitution of a trial by a commission of experts for a trial by jury; whether or not such a remedy would be wise is another question.

Another favorite criticism of experts is the technical jargon which many of them make use of in giving their testimony.

That they do offend in this way no one need, nor, indeed, can truthfully deny; especially is this true of medical experts. Many flagrant and amusing examples of their offending in this given. A surgeon, describing the result of a blow o horse's hoof, uses this language:

"Anterior to the right parietal eminence running parallel with the coronary suture into the squamous portion of the temporal bone, there is a fracture of the bone as long and wide as the finger. Its edges run parallel to each other and are slightly arched with the convexity posterior; the anterior is sharp, the posterior depresses. On the inner surface of the skull the vitreous table is detached and the dura mater lacerated. In addition there was found between the latter and the internal meninges a thick layer of recent blood coagula."

This is, of course, the veriest nonsense, but the remedy is beyond the control of the courts or the Legislature. Neither can control the vocabulary witnesses shall make use of in giving their testimony, whether that witness be an ignorant porter or a learned doctor of medicine. The misuse of a technical vocabulary, so far from reflecting on the witness' qualification, may be taken as indicating his youth or perhaps his want of common sense. This evil, like so many of the others urged against expert testimony, tends to correct itself. The power of punishment is in the hands of the jury and is usually administered by them with judgment and discretion.

Expert witnesses, it is urged, are merely hired advocates whose function it is to make a studied argument under the guise of an oath and in the attitude of a witness, on behalf of the side which engages and pays for their services.

Unfortunately, in many cases this is true; and herein, it seems to me, lies the one grave abuse of expert testimony. This attitude of the witness is responsible for nearly all of their conduct to which exception is taken; it is responsible for the intense partisanship which so discredits the weight of their testimony, and it is the secret of the bad reputation of expert witnesses as a class.

The reasons why the expert witness is so often merely a hired advocate, are, it seems to me, first, the unlimited freedom given to each party to select and call, without limit as to number, his own expert witnesses; second, the absence of any regulation as to the amount of pay or the manner of making it.

To admit the evil and to point out the cause of it is not, however, to find a remedy. Nearly all witnesses, it is true, are more or less partisans. When called and sworn on a particular side of the cause, they become more or less unconsciously interested in the outcome

and yield more or less to the temptation to help along what they are apt to regard as their side of the fight. This is a common defect of human nature with which one must reckon in the administration of justice. While neither commendable nor harmless, it is, perhaps, beyond the reach of any remedy except such as the sound common sense of a jury applies to it; unfortunately a jury is not enough to discredit testimony quite in proportion to the bias and feeling displayed by the witness.

A professional expert witness is, however, almost uniformly a conscious and intense partisan. Many of them are mere intellectual soldiers of fortune. Particularly is this true of handwriting, medical and chemical experts. The business of an expert in these branches has become profitable and a class has grown up who hold themselves ready and willing to give their services as witnesses for hire. The cases in which they are called and in which these defects are exhibited so unpleasantly often involve questions on the frontier of scientific thought as to which no final theory has been accepted. The expert is apt to come with a theory of his own which he has nursed and petted until he has for it all the fondness of paternal affection, and in which he believes as firmly as if it were a scientific truth as long established and as well accepted as the law of gravitation. Naturally, under such circumstances, all the pride and obstinacy of opinion are fully aroused.

In addition to this explainable and more or less natural partisanship, must be charged much that is due to the private right of selection, and of pay. The expert, holding himself, like the lawyer, in readiness to accept employment from the first comer who can pay the price, and who knows his services will not be needed unless his opinion coincides with that of his prospective employer, seeks to form an opinion such as is desired, and then to invent reasons in its support. When thus hired and once enlisted in the warfare, he degenerates into an advocate and no longer occupies the attitude of a witness. If a feasible remedy for this state of affairs could be invented, the cause of justice would be greatly promoted, even though such exhibitions are, it seems to me, comparatively rare in comparison with the number of cases in which resort is had to expert testimony.

A frequent recommendation is to take away from the parties their freedom of choice in selecting and calling experts, and to vest the

right of selection in the courts. Some years ago I was of the opinion that this would be an improvement, but wider experience and more mature reflection have convinced me that it is neither feasible nor wise. The number to be called may be limited, and perhaps the amount of their compensation may be regulated, but each party, so long as trial by jury is to remain unimpaired, must be left free. To deprive a party of that freedom, or to interfere with it seriously, is equivalent to changing the mode of trying the question involved and substituting in lieu of it the experts' investigation and report of a committee selected by the court. The exercise by the courts of the right to select receivers, referees and masters has not been free from criticism. The power of the Judge to control the outcome of the case by appointing the experts, and the temptation it will offer to interested litigants to impose upon the Judge in making the selection, might put the courts to a test which they could not easily sustain. A committee of experts probably making up their minds in secret and certainly reaching their conclusions by arbitrary processes, would be beyond the control of any rule of law.

Moreover, permitting the court to select the experts means, of course, that they must be called by one side or the other. It would be better to take at once the logical step of substituting trial by a commission of experts for the right of trial by jury. This has, indeed, been recommended. The practical difficulties in the way of its adoption are too great to require a serious consideration of it. In the first place, trial by jury is so much a part of the English law, and the English lawyer has been so thoroughly trained in it, that he will be found against the substitution of any other method. The expense of such a commission would be so great that the taxpayers would refuse to support and maintain it. A satisfactory and efficient personnel for a permanent commission would be impossible of attainment, and as a result special commissions would have to be organized for each particular case involving a question of expert testimony. As the required number of desirable experts on many, not to say all matters to be tried by experts, is not to be found easily, the court in impanelling the commission might have to search an entire State, or, indeed, go beyond the limits of a State, to find members. For instance, it is said that there are not more than a score of trained experts in handwriting in the entire United States. If the commis-

sion cannot be efficient, then it is not wise to substitute it for a jury. If a permanent commission for any given territory cannot be provided, then the dangers attending the selection of a special one are too great to be lightly ignored.

I prefer trial by jury in all its impaired vigor, and with all its crudities, to a trial by a court-martial, a legislative committee or a commission of experts. I think justice will be done by it more certainly and more expeditiously than by any of the proposed substitutes.

All of the proposed remedies, with the exception I have already noted, in some way or another encroach on the province of the jury as the arbiter of the facts, and substitutes the judgment of someone else, formed in some way, one knows not how, but not according to the recognized rules and methods of the law of evidence. It is for these reasons that one needs to go slow in radical efforts to root out so-called abuses in expert testimony.

The more one reflects on the subject, however, the more persuaded does one become that most of the criticism is wrongly directed. It is based upon the fact that the experts disagree, and thereby confuse the jury. But, as we have already pointed out, other witnesses disagree and thereby confuse the juries; it is because persons and witnesses disagree that courts are established and trials of issue of fact by a jury are made necessary. Lord Mansfield once said:

"As mathematical and absolute certainty is seldom to be attained in human affairs, reason and public utility require that Judges and all mankind in forming their opinions of the truth of facts should be regulated by the superior probabilities on one side or the other."

It may not be amiss to call attention to the fact that the Anglo-Saxon system of evidence has stood the test of time and experience better than any other department of the English law. The substantive law itself has changed greatly in the past two centuries and is destined to change even more in the years that are to come. Methods of pleading have been entirely changed until the time-honored system of common law pleading has been abolished in England and all her colonies and remains in force in not more than five States of the Union. But in two hundred years there has been but one important or fundamental change made in the law of evidence, and that has consisted in removing disabilities on the competency of

witnesses, in order that even the doubtful evidence of interested persons might not be kept from the jury. We are and have been living in a critical age, in an age in which every child born into the world has a question mark branded on his forehead, and every institution must defend its life against the attacks of the iconoclast; that in an age of this kind the English system of evidence has remained almost unchanged is a proof that it answers admirably the purpose for which it is designed. Of this system expert testimony is an integral part, and while it may often perform no office in a trial except to produce confusion, it is still in all its aspects consonant with the principles upon which the system is established, and ought to be changed only for good and sufficient reasons.

In conclusion, I would suggest to the man who is called as an expert:

First, To testify in no case unless he believes that the cause is just.

Second, To endeavor to become conversant with the facts of the case and with the technical questions relating to all sides of the matter upon which he is to testify.

Third, When on the stand try to be fair and do not argue nor volunteer information.

Fourth, When describing technical matters try to speak in language which ordinary men can understand; otherwise much of the value of the testimony is lost and a bad impression made upon the jury.

Fifth, Never get angry at anything the opposing counsel says.

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Paper No. 1154.

ANCIENT AND MODERN WATER WORKS

By EDWARD WEGMANN

Ooctber 19, 1915

Water is as necessary to life as food, and hence from the earliest times men have built works to secure an adequate water supply. In Egypt these works consisted simply of ditches which were dug for irrigation and water supply. The ruins of only one aqueduct is found in that country, viz., the conduit that supplied ancient Cairo and that is supposed to have been of Roman origin.

This aqueduct led from the Nile to the citadel of Cairo. The water was first raised by chain pumps to a height of 92 feet into a reservoir, from which it was conducted by an aqueduct, having a length of 11,925 feet and a fall of 23.43 feet. The aqueduct is above ground and carried largely by arcades for the first 8,514 feet. This part is not vaulted. For the next 2,428 feet it is underground and lined with masonry. For the last 983 feet the aqueduct is in rock tunnel. Near the end of the aqueduct three wells were sunk for raising water, with chain pumps, in three lifts, respectively 29, 59 and 130 feet.

In Asia Minor there are a number of ruins of aqueducts, some of which were constructed in a very remote period of history, and others which were built by the Romans. One of the oldest of these ruins is that of the Aqueduct of Patara which is described below.

The Aqueduct of Patara

The Aqueduct of Patara in Syria, is one of the oldest works of its kind. It was built across a ravine, which has a maximum w... of 200 feet and a depth of about 250 feet. The height of th... duct wall, built across the valley is, however, considerably l... the figure just named, as the wall is made, on both sides, by ... ing inclines, only the central part being horizontal. Th...

made by the north and south inclines with the horizontal part are respectively 156° and 169°.

The wall has two faces, formed of large, irregular blocks of stone. The space between the faces was filled with stone, laid in sand. The siphon-conduit on the wall consisted of stone blocks, each containing about 3 cubic feet. Each stone block was bored through the center to a diameter of about 13 inches, and had an annular projection at one end and a recess, about 3 inches deep, at the other, the blocks being connected by a kind of "hub-and-spigot joints." These were filled with cement and were made still more secure by uniting the blocks by iron clamps, run with lead. Air vents, 7 inches in diameter, were provided on the siphon, at intervals of about 20 feet.

Broken earthen pipes are found along the wall. They were probably used for an earlier siphon, laid before the stone blocks were resorted to. The Patara aqueduct wall is still in a very good state of preservation and is considered one of the finest ruins of early Greek construction. The siphon is continued by a horizontal canal, covered with large slabs of stone.

Aqueduct of Jerusalem

This aqueduct was built to convey water from reservoirs near Bethlehem, known as Solomon's pools, to Jerusalem. The work has been attributed to Solomon and was probably constructed about his time, although Josephus does not mention the fact. According to descriptions given by several travelers, the aqueduct consisted of earthen pipes, about 10 inches in diameter, each pipe being encased by two stones, cut to fit. The pipes, thus strengthened, were placed on stone foundations and covered with rough stones, laid in mortar. The aqueduct, which was about 12 miles long, took a circuitous route around the hills, the whole work being generally below the surface; but, in crossing the plain at Jerusalem, the aqueduct was built mostly above ground It terminated just west of the Temple, for which the water was specially needed.

Solomon is said to have had a house and garden near the pools named after him, where the "sealed fountain," from which the conduit conveyed the water was located. The reservoirs are still in existence and remains of the aqueduct are found at many places. At one point the aqueduct was carried by a bridge across a stream.

THE AQUEDUCT OF LAODICEA

The ancient city of Laodicea, in Asia Minor, had a good water supply. Extensive ruins of its aqueduct are still to be seen. Before reaching the city the water was conveyed across a deep valley, by two lines of stone pipes, forming inverted siphons, most of which are still on the ground in perfect condition. The pipes consist of large blocks of limestone, which were bored out. The lowest point of this

Fig. 1.—Aqueduct of Athens.

siphon is about 138 feet below the highest part of Laodicea, and the pipes sustained, therefore, a pressure of about 60 lbs. per square inch. The pipes were not laid in a straight line across the valley, but on a sinuous course, probably with a view of breaking somewhat the force of the water.

The pipes on the west line are somewhat larger than those in the east row, the inner diameter of these pipes being respectively about 10 inches and 8 inches. The average size of the blocks, which were bored to make the pipes, was about 3 x 3 x 2.75 feet for the west row and about 2.5 x 2.75 x 5.5 feet for the east row. The joints of the pipes were made in hub-and-spigot fashion. At certain intervals, conical vent holes were cut in the stones, to permit the air to escape when the pipe lines were being filled and to enable the man in charge of the work to locate obstructions that might get into the pipes. The mortar with which those holes were, doubtless, filled has now all disappeared.

In a similar line of stone pipes, in the aqueduct that supplied ancient Pergamum, a Greek city in Asia Minor, about 50 miles north of Smyrna, the joints between the pipes are filled with mortar, and one of the vent holes is closed by a stone ball, which was probably kept in place by mortar.

In Greece pipe lines similar to those described above were laid in a number of places for water supply, and some aqueducts were, also, constructed, usually underground, to hide the conduit from an enemy. One of the oldest of these works was the aqueduct of Athens (Fig. 1), built about 500 B. C.

Roman Aqueducts

The Romans were the greatest builders of aqueducts in ancient times. Ruins of their works are to be found in many places in Europe and in Asia Minor.

The City of Rome was supplied with water in the first century of the Christian era by nine aqueducts. Sextus Julius Frontinus*, who was appointed about 97 A. D., curator aquarum—caretaker of the aqueducts, or as we would now say, Commissioner of Water Supply—wrote a detailed description of these aqueducts, which has been translated into French, German and English. We are indebted to Frontinus for most of the information we have about these nine

*Frontinus was born of a Patrician family about 35 A. D., and died in 107 A. D. He was made praetor in 70 A. D., and was three times consul. He distinguished himself as a soldier, and was made governor of Britain. Prior to writing his description of the aqueducts of Rome, he had written treatises on "Surveying" and "The Art of War."

aqueducts. His book is read by engineers with as much interest now, as when it was wirtten.

For the first 441 years after the foundation of Rome, the citizens obtained their supply of water from the river Tiber, which flows through the city, or from springs.

The first aqueduct for Rome was built about 312 B. C., to obtain for the city water from some springs near the Anio River, an affluent of the Tiber. It was about 10 miles long, and was built entirely under ground, with the exception of an arcade, about 60 paces long,

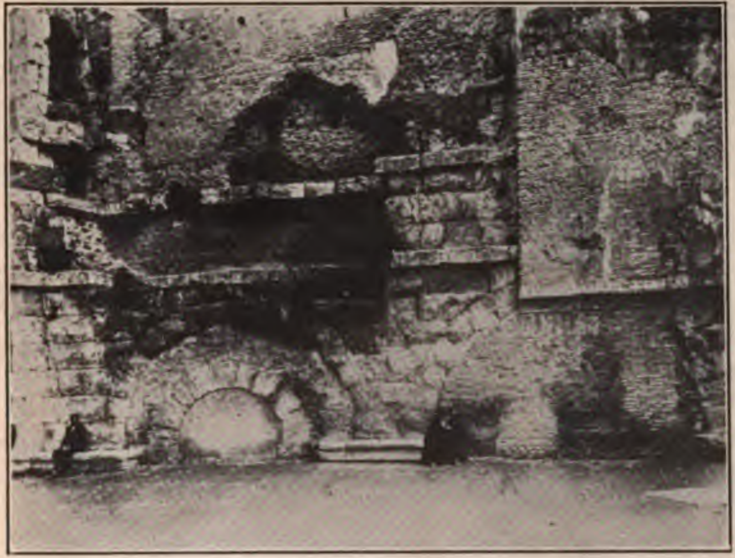

Fig. 2.—Aqueducts of Marcia, Tepula and Julia.

near the city's wall. The work was done under the direction of the censor, Appius Claudius Crassus, and was named after him: The Aqua Appia—Appian Water.

The second aqueduct was constructed in 272-269 B. C. to bring water from the river Anio to the city. It tapped this river, about 20 miles east of Rome, but, owing to the circuitous location adopted to avoid the crossing of valleys, the aqueduct had a length of about 4(miles. This supply was known as the Aqua Anio Vetus—the O Anio Water. With the exception of about a length of 1-5 mile, tl

aqueduct was also built under ground. The expense of the construction was defrayed out of the spoils of the Pyrrhic War.

About 125 years later (144-140 B. C.), a third aqueduct had to be built for Rome. The work was carried on under the direction of the Praetor Q. Marcus Rex, after whom the conduit was named the Aqua Marcia. Springs in the mountains near Subiaco, known for their coolness and salubrity, were selected as the source of this supply. The water brought by this conduit to Rome was the best the city ever had. Pliny says of it: "Of all the waters in the world, that, which we call the Marcia, carries the greatest name by the general voice of the citizens, in regard both to its coldness and salubrity, and we may esteem this water one of the greatest gifts the gods have bestowed on our city." The aqueduct had a length of 57 miles, of which 50 miles were built underground.

Fifteen years later the water supply of Rome had again to be increased. The new supply was obtained from springs in the volcanic rocks southeast of the city. The conduit conveying the water to the city was about 12 miles long. About half of it was built above ground, and it was carried into the city on top of the Marcian Aqueduct. Owing to the warm temperature of its water, this aqueduct was called Aqua Tepula (tepid water).

The four aqueducts described above furnished Rome with an adequate water supply for ninety-two years, viz. to 33 B. C. An additional aqueduct was then required. Its supply was obtained from springs near the source of the Aqua Tepula. The new conduit, which was named the Aqua Julia, in honor of the emperor Julius Caesar Augustus, had a length of about 14 miles. For part of its length it was built on top of the Aqua Tepula. Near the walls of the city, the Marcian arches carried three aqueducts, one above the other, viz. the Marcia, Tepula and Julia (Fig. 2). The work was performed under the direction of the Aedile M. Vipsannius Agrippa.

About fourteen years later (19 B. C.), the Aedile Agrippa, who had built the Aqua Julia, brought another supply of water to the city. Springs near the Anio River formed the source of this supply. They were pointed out by a young girl (virgo) to some soldiers who were looking for water, and this circumstance gave the new aqueduct its name, viz. Aqua Virgo. The conduit was 13 miles long and was built, with the exception of one mile, below ground.

Fig. 3.—Aqueduct of Claudia and Anio Novus.

Fig. 4.—Claudia and Anio Novus Aqueducts.

All of the aqueducts described above obtained their supplies to the east of Rome. About 10 B. C. the emperor Caesar Augustus had water from the Lake Alsietinus, lying about 14 miles northeast of the city, brought to Rome. The new aqueduct—known as the Aqua Alsietinus—was about 20 miles long, and was built almost entirely below ground. This water was unwholesome and was delivered at a very low level. The main object for which this conduit was built, was to obtain an adequate supply for the Naumachia, an artificial oval lake, 1742 feet long by 1161 feet wide, on which sham naval battles were fought.

Fig. 5.--Plan of Rome.

For about fifty years Rome had enough water, but by 38 A. D. the supply had again to be increased, owing to the growth of the population and the luxurious habits of the people. Two new aqueducts were built in 38-52 A. D. The work was begun during the reign of the Emperor Caligula, and was completed by the Emperor Claudius, after whom one of these conduits was called the Aqua Claudia. It derived its supply from two fine springs, lying about 38 miles from Rome. This aqueduct was about 43 miles long. For 9 miles of its length it was built above ground. Near Rome it was carried by a fine arcade, 6 miles long (Figs. 3 and 4).

The second of these aqueducts, known as the Aqua Anio Novus—the New Anio water—tapped the Anio River, about 42 miles from Rome. As the river carried much sediment after rain storms, a settling basin had to be built at the inlet of the aqueduct, but, in spite of this precaution, the water reached the city much discolored after heavy rains. This aqueduct was 54 miles long. For 9 miles of its length it was above ground—generally on top of the Claudian Aqueduct.

The principal data of the nine aqueducts described above are given in the following table:

ROMAN AQUEDUCTS, DESCRIBED BY FRONTINUS 97 A. D.

Name	Date	Length in Miles Below ground	Length in Miles Above ground	Total	Height of water above quary of Tiber in feet	No. of Castellae	Total Supply in Quinariae
Aqua Appia ...	312 B. C.	10.23	.06	10.29	27.5	20	704
Anio Vetus ...	272-269 B. C.	39.33	.30	39.53	82.6	35	1610
Marcia	144-140 B. C.	49.87	6.86	56.73	123.0	51	1935
Tepula	125 B. C.	5.51	6.44	11.95	125.4	14	445
Julia	33 B. C.	7.75	6.44	14.19	130.3	17	803
Virgo	19 B. C.	11.83	1.14	12.97	34.2	18	2504
Alsietinus	10 B. C.	19.96	.33	20.29			392
Claudia	38-52 A. D.	33.31					
			9.35	42.66	155.6	92	5625
Anio Novus ..	38-52 A. D.	45.32	8.64	53.96	155.6		
Total		223.11	39.46	262.57		247	14,018

Some additional aqueducts and branch conduits were built subsequent to Frontinus' time. The principal of these works are mentioned below.

The Aqua Trajana was built in 109 A. D. by the Emperor Trajan to bring water from springs north of Lake Sabatinus (now Lago di Bracciano) into the city. At a later period this aqueduct drew water direct from the lake.

The Aqua Hadriana was built in 120 A. D. by the Emperor Hadrian. Originally this aqueduct brought water only to the great villa of the emperor, near Cento Celli, about 5 miles from Rome. About 226 A. D. it was extended to Rome.

The Aqua Aurelia was built by Marcus Aurelius in 185 A. D. to convey water from springs near Mariano to his villa on the Via Appia This aqueduct was extended in 196 A. D. to Rome by Septi Severus, after whom the conduit was then named Aqua Severi

Besides the twelve principal aqueducts described above, a number of branch conduits were built to distribute the water.

The location of the aqueducts is shown in Fig. 5 and their cross-sections are given in Fig. 6. It will be noticed that no two cross-sections are alike. Each conduit has its own peculiar cross-section, which made it easy to identify it.

Sources of Supply

The old Romans were very careful in selecting a source of supply. They judged the wholesomeness of the water by the health of the people using it. With three exceptions, the twelve aqueducts described above all drew their supply from springs.

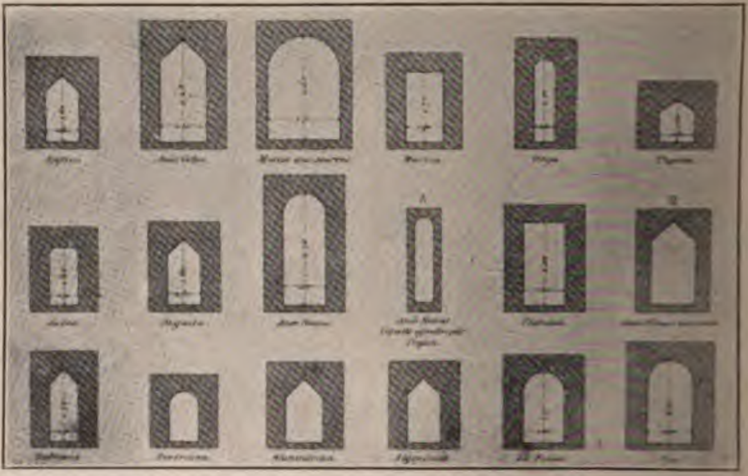

Fig. 6.—Cross Sections of Roman Aqueducts.

Location

The Romans had no suitable material for making water pipes. Lead was used for this purpose, but was expensive. It was used mainly for distributing pipes in the city. For this reason the Romans avoided crossing valleys, and followed the proper contours of hills as closely as possible. This increased the length of the old aqueducts very materially. A modern engineer could reduce the length of some of these locations by one-half by using inverted siphons of pipes.

The grades adopted for the old Roman aqueducts were much steeper than those of modern aqueducts. They varied from about 1 in 600 to 1 in 3000. In some of the conduits the grades were quite regular, while in others they varied very much. The steepness of the grades was, probably, largely due to the primitive leveling instruments, used by the Romans, which made great accuracy impossible. One kind was a water-level, consisting of a copper tube, about 5 feet long, having both ends turned up. This tube was filled with water to a convenient height. By sighting a certain distance above the water shown in the two ends of the tube, a level line could be produced. The most reliable leveling instrument was known as "the chorobates" (Fig. 7). It was a straight-edge, about 20 feet long, having at its center a small water channel, about 5 feet long. When this channel was partly filled with water, the instrument could be roughly leveled, but the main aid to making the top of the rod horizontal

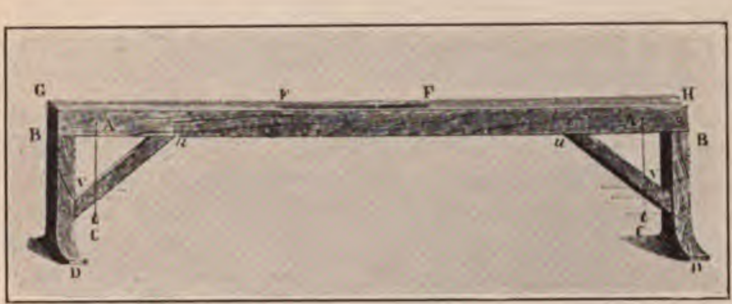

Fig. 7.—Roman Level.

consisted of two plumb-bob lines, one near each end of the rod, which had to cover scratch marks on the instrument, when it was level. The engineer—or rather the architect, for it was he who built the Roman aqueducts—sighted over the top of the rod and thus ran levels, as we do with our modern leveling instruments.

Details of Construction

As already stated, the aqueducts were constructe part in tunnels. They were driven by means of placed usually 240 feet apart, a distance equal to

A strong growth of vegetation exists now at these old shafts, and enables us to trace the location of the old aqueduct tunnels. Where rock was encountered in the tunnels, it was removed by the "fire-setting system," which consist in heating the rock by means of fires, and of cooling it suddenly with water. Until recent times, some German mines have been excavated by this system.

The early aqueducts were built of dry cut-stone masonry with the exception of a lining, 4 to 6 inches thick, for the water channel. This lining consisted of a kind of concrete, made of crushed pottery mixed with quick-lime and sand. At a later period, rubble masonry and brick work were used in the construction of the aqueducts. The Roman bricks were triangular in shape, and about 1½ inches thick.

The bottom of the water channel was left rough, probably in order to check the velocity of the current, to keep back sediment, and to aerate the water. Perhaps it was for the same purpose that numerous angles were introduced in the location of the aqueducts. They occur about once every half mile. Some writers have thought, however, that these angles were due to difficulties experienced in acquiring the necessary right of way.

At each of these angles a small reservoir (castellum) was built, and occasionally a settling basin (piscina). These reservoirs served as points of distribution of the water, and, also, as blow-offs. Each settling basin had two upper and two lower chambers. The water entered the first upper chamber and passed down, probably through a pipe, to the first lower chamber. It then passed through numerous small holes into the second lower chamber, and rose through a hole in the roof of this chamber to the second upper chamber. In following this circuitous path, the water left most of the sediment it carried in the lower chambers. When these chambers had to be cleaned, the water could be shut off from the lower chambers by means of suitable sluices, and would flow then directly from the first upper chamber to the second one.

Ventilators (luminae) were built at frequent intervals along the line end of each aqueduct. They were provided with steps which gave access to the aqueduct, and served sometimes as wells, where water could be drawn out of the aqueduct by means of buckets.

Distribution of Water

The aqueducts terminated in the city in large reservoirs (castella

publica), some of which received the water of several conduits. By means of lead pipes, water was conveyed from these reservoirs to smaller reservoirs or cisterns, (castella privata) each of which was usually built by several consumers, who clubbed together for this purpose. From these cisterns the water was taken, usually in lead pipes, to the domestic cisterns in the courtyards of the houses. In the time of Frontinus there were 247 public and private reservoirs in Rome. Ruins of many of them are still to be seen.

The service pipes (Fig. 8) were usually made of lead and given a piriform shape. Each pipe was uniformly 10 Roman feet (9.8 English feet) long. It was made of sheet lead, about ¼ inch thick, which was bent to the proper shape. The longitudinal joint on top of the pipe was made by forming a channel by means of clay on each side of the joint, and filling the channel with molten lead, a mixture of different kinds being used. The name of the contractor, who laid the pipe, and usually also of the owner, was stamped on the pipe.

Consumption of Water

Upon assuming charge of the water works of Rome, Frontinus made a careful inspection of each of the nine aqueducts, and gauged its capacity. Unfortunately, he simply measured the wetted area of each water channel and paid no attention to the velocity of the water. By dividing the wetted area of each aqueduct by the area of a standard pipe, called a quinaria, he obtained the number of pipes the aqueduct would supply. Here again he made a serious mistake, as the friction in a water pipe depends on its hydraulic radius, which is the wetted area, divided by the wetted perimeter. In flowing through a number of small pipes, a certain quantity of water encounters more friction than in passing through one large pipe. Frontinus gives us the capacity of each aqueduct, determined by his faulty method, in an equivalent number of quainariae, the area of each being 0.632 square inches, about equal to that of a circle 0.9 inches in diameter.

Based upon erroneous assumptions, a French engineer, M. delet, computed the discharge of a quinaria pipe to be U. S. gallons in 24 hours. By multiplying the number of given by Frontinus as the capacity of the nine aqueducts of

this figure, Rondelet estimated the water supply of Rome in 97 A. D. to have been about 393,000,000 U. S. gallons; the population of the city being then about 1,000,000.

This erroneous estimate found its way into a number of encyclopedias. Even though the rich Romans used water lavishly, that was not done by the poorer classes. It must, also, be remembered that the water used in the Roman houses had to be carried in jars from the private cistern into the house.

Mr. Clemens Herschel* has made a much more rational estimate of the probable water consumption in Rome in 97 A. D. According

Fig. 8.—Roman Lead Pipes.

to Herschel the total daily delivery of the nine aqueducts was only about 84,000,000 U. S. gallons, of which quantity probably only about 54,000,000 gallons were distributed within the walls of the city.

Repairs of the Aqueducts

While the Romans built grand aqueducts, they did not maintain them in good condition. This neglect was caused partly by the peculiar laws that existed at that time. According to one of these laws, the men in charge of the aqueducts, called the aquarii, were

*Frontinus and his eleven books on the Water Supply of the City of Rome, 97 A. D. by Clemens Herschel.

permitted to sell all the water that leaked from the conduits. When a leak occurred these men were prone to encourage it, instead of trying to stop it.

Another peculiar law obliged the Commissioner of Water Supply to give only one quarter of his time to his public duties. It appears that some of these commissioners took public contracts on which they employed the men who were supposed to take care of the aqueducts.

Frontinus tells us that, at times, two or three of the nine aqueducts did not deliver a drop of water into the city. This was partly due to their leaky condition, and partly to the fact that rich and influential people diverted the water to their villas, before it could reach the city.

Roman Aqueducts in Various Places

Wherever the Romans founded a city, one of the first works they undertook was the construction of an aqueduct for obtaining an adequate supply of pure and wholesome water. More than two hundred ruins of Roman aqueducts are to be found in various parts of Europe and Asia Minor. A brief mention of some of the most important of these works is given below.

The Aqueduct of Nismes

in the southern part of France, was built in the first century of the Christian Era to bring a water supply to the city of Nemausis (now Nismes). It was about 30 miles long and had a general grade of about 3 feet per mile. Its water channel was generally about 4 feet wide by 5 feet high, but in tunnels the height was increased to 7½ feet.

The most remarkable part of this aqueduct is the crossing of the deep valley of the river Gard, about midway between the springs that furnish the water supply and the terminus of the aqueduct. This crossing was effected by means of an arcade, about 160 feet high, known now as the Pont du Gard (Fig. 9) which is still in an excellent state of preservation. The arcade is composed of three tiers of semi-circular arches. The lowest tier contains six arches: one of 80 feet span, three of 51 feet span and two of 51 feet spa
The second tier contains eleven arches, each of 51 feet span.

the third tier there are thirty-five arches, each of about 16 feet span. The width of the arcade at the first, second and third tier is respectively 21, 16 and 10 feet. Some of the arches at each end of the structures have been destroyed. The present length at the moulding terminating the second tier is 883 feet. The whole structure is built of dry masonry, mortar being only used in the concrete forming the lining of the water channel.

The Aqueduct of Lyons

The ancient city of Lugdunum (now Lyons, France) was supplied by four grand aqueducts, built during the reigns of the Roman emperors Augustus, Tiberius and Claudius. The most famous of these conduits are known as the Claudian aqueduct. It was about 33 miles long and had a total fall of about 360 feet in this distance. There were nine arcades on the line of this conduit. A valley, about 200 feet deep, was crossed by an arcade, 2,400 feet long, having five tiers of arches. Another valley, about 300 feet deep, was crossed by an arcade having eight tiers of arches. Three deep valleys were crossed by siphons of lead pipe, 1 inch thick. The pipes were generally surrounded by masonry to give them additional strength. At one valley nine lines of pipes were used; at another there were twelve siphon pipes.

The Aqueduct of Metz, France

Ruins of an important Roman aqueduct are found near Metz. The date of its construction is unknown, but the work is supposed to have been built during the first century of the Christian era. The aqueduct had a length of about 15 miles and a total fall of about 73 feet. Its section was 3 feet wide by 6 1-3 feet high, the top being rounded. The aqueduct was built in a similar manner as those of Lyons, but had no siphons. One of its arcades had a length of about 3,600 feet and a maximum height of about 100 feet. In this aqueduct the conduit on the arcades was divided by a central wall into two water channels, one of which could be kept in service, while the other was being cleaned or repaired. The aqueduct crossed the river Moselle on a high arcade of one range of arches, at a point about two leagues from Metz, where the stream has considerable width. Out of 118 arches of this arcade, five are still standing perfectly solid,

on the left bank, and 17 on the right. Branch conduits conveyed water from the aqueduct to the Roman baths and to a place where representations of naval engagements were given. For the latter purpose water from the river Gorze was likewise conducted by tunnels to a great reservoir where the exhibition of sea fights took place.

THE AQUEDUCT OF SEGOVIA, SPAIN

is supposed to have been constructed in the time of the Emperor Trajan, in the first century of the Christian era. Near the City of Segovia the aqueduct is carried by an arcade, 2,400 feet long with a maximum height of about 102 feet (Fig. 10). It contains 159

Fig. 9.—Pont du Gard.

semi-circular arches. Those of the lower tier have arches of 17 feet span. In the upper tier the spans vary from 14 to 15 feet. The whole arcade is built of cut stone, laid dry, no cement being used in the masonry, except in the lining of the water channel. This aqueduct still supplies the city of Segovia with water.

THE AQUEDUCT OF SEVILLE

in Spain, was probably built by the Romans, but it has been repaired at various times in a manner which has obliterated its style of architecture. Its present arches are of unequal spans and ver rough in appearance. The water channel has been allowed to becor very leaky, but it furnishes nevertheless an abundant supply

water from Alcala, which is many miles from Seville, for most of the houses of the latter place.

The Aqueduct of Taragona

Spain, had an arcade 876 feet long and 83 feet high.

Water Supply of Modern Rome

By the middle of the sixth century, the supply from all the aqueducts had been cut off from Rome by the barbarians or by neglect of the aqueducts. From this time until 776 A. D. Rome had to depend for its water supply on the river Tiber and on springs. In 776 A. D. the enlightened Pope Adrian I commenced to restore the Trajana, Marcia, Claudia and Virgo aqueducts. For a short time Rome had again a good water supply, but it was soon again stopped and the city remained without a proper water supply until 1447 A. D. when Pope Nicholas V put the Virgo aqueduct again into service. This conduit is now known as the Acqua Vergine.

The Acqua Felice was built in 1585-1587 by the Pope Sixtus V (Felice Peretti) after whom it was named. It derives its supply from springs that furnished water to the Hadriana.

The Acqua Paola

About 1618 Pope Paul V restored the old Trajana to use. It is named after him the Acqua Paola.

The Acqua Pia

was constructed by a private company in 1860-1870 to introduce into Rome again the excellent spring water that had supplied the Aqua Marcia. This conduit was named after Pope Pius IX, who took a lively interest in this work, the Acqua Pia.

The four aqueducts described above furnish the water supply of Modern Rome. Their lengths, capacities, etc., are given by Rodolfo Lanciani in his "Ruins and Excavations of Ancient Rome," as follows:

Water Supply of Modern Rome

Aqueduct	Date	Author	Lengths in meters	Delivery in 24 hours in cubic meters
Vergine	1570	Pope Pius V	20,546	155,271
Felice	1587	Pope Sixtus V	32,593	21,634
Paola	1611	Pope Paul V	51.852	80.870
Pia	1870	Societa dell-aequa	53.649	121.306

According to the above table the total available supply of Rome is 100,130,000 U. S. gallons per 24 hours.

Water Supply of the City of New York

Having described the great water works of ancient times, we shall now consider modern water works. The greatest among these are, without doubt, those that supply the City of New York, the metropolis of America.

This city was founded in 1611. At first the citizens obtained their water supply from springs and brooks. Later public wells were sunk

Fig. 10.—Aqueduct of Segovia.

and served for furnishing water, not only for domestic supply, but, also, for extinguishing fires. The first public well was sunk, about 1658, in front of the old fort at Bowling Green. It was the only public well until 1677, when the Burgomasters ordered some additional wells to be sunk.

The first public water works were constructed in 1774. Th
ply was obtained from a deep pond, known as "the colle
was pumped by means of steam engines to a reservoir, co

on the east side of Broadway, between Pearl and White streets. The works were soon abandoned, on account of the confusion caused by the revolution. After the restoration of peace, the subject of securing an ample supply of pure and wholesome water was repeatedly agitated, but for a long time without results. In 1799 Aaron Burr obtained a charter for the Manhattan Water Company, which was to supply the city with wholesome water, but it soon became evident that this company was really a bank in disguise. It is now called the Manhattan Bank. The supply of water which this company furnished was inadequate in quantity and unsatisfactory as regards quality. This condition lasted for more than thirty years, and all efforts to construct public water works were defeated by the silent, but powerful, opposition of the Manhattan Water Company.

In response to the appeals of the City's Common Council, the State Legislature passed in 1833 a law authorizing the appointment of a commission which was to investigate the best means of securing a satisfactory water supply for the City of New York. This commission recommended that the supply be obtained from the Croton River, an affluent of the Hudson River, which empties into this river on its east bank, about thirty miles from New York. The necessary works were authorized by the Legislature in 1834, and were constructed in 1837 to 1842. A dam, about 50 feet high, was built across the Croton River to form a "fountain reservoir," and the water was conveyed by a masonry aqueduct, 38 miles long, from this reservoir to a receiving reservoir, constructed on land which now forms part of Central Park. Three 36-inch water mains conveyed the water from the receiving reservoir to a distributing reservoir on Murray Hill, at Fifth Avenue and 42nd Street. The total length of the aqueduct and pipe line is 40½ miles.

The aqueduct is 8 feet 5½ inches high and 7 feet 5 inches wide at the spring line of the arch. According to the original plans, it was only to be filled to the spring line of the arch, at which level its capacity was estimated at 36,000,000 gallons for 24 hours. Owing to the rapid increase in consumption, the water level in the aqueduct was raised by 1889 to the crown of the arch, and the discharge was increased thereby to about 95,000,000 gallons per 24 hours.

One of the finest structures on the line of the Croton aqueduct—now called the Old Croton Aqueduct, in order to distinguish it from

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on the east side of Broadway, between Pearl and White streets. The works were soon abandoned, on account of the confusion caused by the revolution. After the restoration of peace, the subject of securing an ample supply of pure and wholesome water was repeatedly agitated, but for a long time without results. In 1799 Aaron Burr obtained a charter for the Manhattan Water Company, which was to supply the city with wholesome water, but it soon became evident that this company was really a bank in disguise. It is now called the Manhattan Bank. The supply of water which this company furnished was inadequate in quantity and unsatisfactory as regards quality. This condition lasted for more than thirty years, and all efforts to construct public water works were defeated by the silent, but powerful, opposition of the Manhattan Water Company.

In response to the appeals of the City's Common Council, the State Legislature passed in 1833 a law authorizing the appointment of a commission which was to investigate the best means of securing a satisfactory water supply for the City of New York. This commission recommended that the supply be obtained from the Croton River, an affluent of the Hudson River, which empties into this river on its east bank, about thirty miles from New York. The necessary works were authorized by the Legislature in 1834, and were constructed in 1837 to 1842. A dam, about 50 feet high, was built across the Croton River to form a "fountain reservoir," and the water was conveyed by a masonry aqueduct, 38 miles long, from this reservoir to a receiving reservoir, constructed on land which now forms part of Central Park. Three 36-inch water mains conveyed the water from the receiving reservoir to a distributing reservoir on Murray Hill, at Fifth Avenue and 42nd Street. The total length of the aqueduct and pipe line is 40½ miles.

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ASTOR, LENOX AND TILDEN FOUNDATIONS

a later conduit, named New Croton Aqueduct—is High Bridge, (Fig. 13) a fine bridge across the Harlem River, which is 100 feet high from high-water to the crown of the arches. Three pipes, placed in a vault, two of 36 inches diameter, and one of 90½ inches diameter, convey the Croton water across the bridge.

The first Croton water was introduced into New York on July 4, 1842. The total cost of the Old Croton Aqueduct and reservoirs was about $9,000,000.

Owing to the wonderful growth of New York, additional reservoirs had soon to be constructed in the Croton water shed, to store the excess of water during floods for periods of drought.

A list of these reservoirs, built to date, is given in the following table:

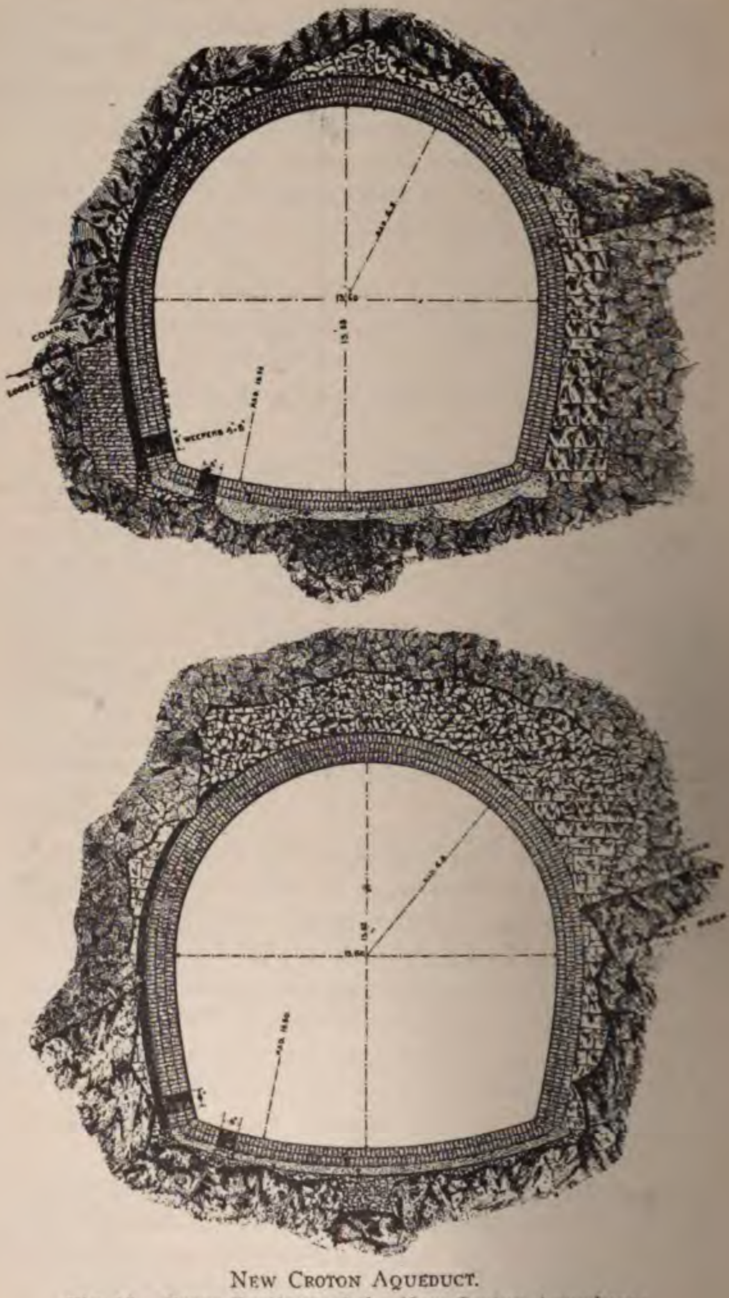
STORAGE RESERVOIRS IN THE CROTON WATER SHED

Name of Reservoir	Put in Service	Capacity in gallons
Old Croton Lake	1842	
Boyd's Corners	1873	2,727,000,000
Middle Branch	1878	4,155,000,000
East Branch (Sodom)	1891	5,243,000,000
Bog Brook	1891	4,400,000,000
Titicus	1893	7,617,000,000
West Branch (Carmel)	1895	10,668,000,000
Amawalk	1897	7,086,000,000
New Croton	1905	33,815,000,000
Cross River	1908	10,923,000,000
Croton Falls	1911	15,753,000,000
Total		102,387,000,000

In addition to the above reservoirs, the city owns a number of small lakes and ponds from which it can draw about 2,810,000,000 gallons. Including these lakes and ponds, the total available storage in the Croton watershed amounts to 105,197,000,000 gallons.

By 1875 the Old Croton Aqueduct was strained to its utmost capacity to supply the consumption of water in New York. The construction of a second aqueduct from the Croton Valley to the city was urged, but the work could not be undertaken, owing to the deplorable condition of the city's finances, resulting from mismanagement.

A small additional supply of about 22,000,000 gallons per day was obtained in 1884 to 1890 from the Bronx and Byram rivers, and conveyed in a 48-inch pipe line to a receiving reservoir, constructed at Williams bridge in the present borough of the Bronx.



New Croton Aqueduct.
Fig. 12.—Cross Sections of the New Croton Aqueducts.

By 1883 the city's finances had recuperated sufficiently to permit the construction of a new aqueduct. An act, passed by the State Legislature in 1883, authorized the construction of the new aqueduct and, also, of the necessary new reservoirs. The work was entrusted to a Board of Aqueduct Commissioners, whose membership was changed from time to time by supplementary acts. This commission was organized in 1883 and was finally abolished on June 1, 1910, its remaining work being transferred to the Department of Water Supply, Gas and Electricity.

The first work undertaken by the Aqueduct Commissioners was

Fig. 13.—High Bridge.

the construction of a second conduit from the Croton Valley to the City of New York. It is known as the New Croton Aqueduct, and has a capacity of 300,000,000 gallons per day. This conduit was constructed in 1885 to 1891. It consists of three parts: First, a gravity section 23.92 miles long, built on a grade of 0.7 feet per mile, according to the horseshoe cross-section, shown in Fig. 12; Second, a circular pressure tunnel, 6.83 miles long, having an inner diameter of 12.25 feet, with the exception of the tunnel under the Harlem River, which has a diameter of 10.5 feet and a length of about 1,200

Fig. 14.—New Croton Dam.

Fig. 15.—Spillway, New Croton Dam.

feet; Third, a pipe line, 2.37 miles long, consisting of eight lines of 48-inch cast iron mains. The total length of the aqueduct from Croton Lake to the receiving reservoir in Central Park is 33.12 miles.

The New Croton Aqueduct was constructed entirely in tunnel, with the exception of a few short stretches, aggregating 1.12 miles, where the conduit was built in open trenches, and with the exception of the pipe line. The conduit begins at a large inlet gate house, built at Croton Lake, and terminates at a gate house at 135th Street and Convent Avenue, at which the pipe lines begin.

A large receiving reservoir, known as the Jerome Park Reservoir, was to be built in the borough of the Bronx. It was to have two basins, storing together about 1,900,000,000 gallons. The westerly basin, having a capacity of about 800,000,000 gallons, has been completed, but work on the easterly basin was stopped about 1903, as the construction of a filter was contemplated on the ground the basin was to occupy.

Under the direction of the Aqueduct Commissioners seven large storage reservoirs were built in the Croton watershed. Their capacities are given on page 343. The most important of these basins is the New Croton Reservoir, which was formed by building a high masonry dam, known as the New Croton Dam, across the Croton Valley, about three miles below the Old Croton Dam.

The New Croton Dam (Figs. 14 and 15) was built in 1895 to 1907. It has a length of crest of about 2,200 feet including the spillway, which is built along the north side of the valley, almost at right angles to the main dam. The maximum height of the dam, from the lowest point in the foundation to the crest of the dam, is 297 feet. The high water mark in the reservoir formed by this dam is 30 feet higher than the high water mark of the Old Croton Reservoir. The cost of the New Croton Dam, including the construction of new highways, etc., amounted to about $7,600,000.

The Catskill Water Supply

The minimum yield of the Croton water shed, with the storage reservoirs, lakes and ponds mentioned on page 343, is estimated at about 290,000,000 gallons a day. The boroughs of Manhattan and the Bronx were consuming more than this quantity of water by 1905,

and the other three boroughs of the Greater New York (Brooklyn, Queens and Richmond) were short of water. It was, therefore, necessary to secure, without delay, an additional source of supply for New York.

In 1902 a commission of engineers, composed of Prof. Wm. H. Burr, Rudolf Hering and John R. Freeman, made an exhaustive report on the best way of increasing the water supply of New York to the Commissioner of Water Supply, Gas and Electricity. This commission recommended that an additional supply of 250,000,000 gallons be obtained from streams in Dutchess County, immediately north of the Croton water shed, and an equal quantity from water sheds in the Catskill mountains. A law, passed by the State Legislature in 1904, prohibited the City of New York from diverting water from Dutchess County, and the city was, therefore, obliged to secure its whole additional supply from the Catskill water shed. In 1905 an act was passed that gave the city the necessary authority to obtain this supply. The construction of the necessary works was entrusted to a Board of Water Supply, composed of three members, which was organized in the summer of 1905. J. Waldo Smith was appointed chief engineer of this commission, and John R. Freeman, Prof. William H. Burr and Frederick P. Stearns were retained as consulting engineers. The construction of the works was begun in 1906 and will be practically completed by the end of 1915.

Figs. 16, 17 and 18 show the general plan of the Catskill water works. The supply is to be secured from four principal water sheds in the Catskill mountains, which will yield together with some small contiguous water sheds a minimum supply of about 900,000,000 gallons per day. Thus far, works have only been built on one of these streams, viz., on Esopus Creek, on which a storage reservoir having an available capacity of 128,000,000,000 gallons has been constructed. This basin, known as the Ashokan Reservoir, has been formed by the construction of a masonry dam, which is flanked on both sides by earth dams, aggregating 3,650 feet in length. The masonry part of this structure, known as the Olive Bridge Dam, is 1,000 feet long and has a maximum height of 240 feet above the foundation of Esopus Creek. The water shed above the Ashokan dam contains 255 square miles and is capable of furnishing a minimum daily supply of 250,000,000 gallons.

From the Ashokan Reservoir the water is to be conveyed to the City of New York by an aqueduct having a capacity of 500,000,000 gallons per day. This aqueduct, which is 92 miles long, terminates at the Hill View Reservoir, an equalizing reservoir of 900,000,000 gallons capacity, constructed on high ground at the north boundary of New York. The Catskill Aqueduct was constructed according to four types, which are shown in Fig. 19, as follows:

CATSKILL AQUEDUCT.

Cut-and-cover	55 miles
Grade tunnel	14 miles
Pressure tunnel	17 miles
Siphon pipes	6 miles
Total	92 miles

The dimensions of the different types of aqueduct are given in Fig. 19. Each siphon is to consist eventually of three lines of steel pipes, of which only one has thus far been laid. The steel pipes are lined on the inside with two inches of cement mortar, enveloped with concrete and covered with an earth embankment.

A large storage basin, known as the Kensico Reservoir, is being constructed on the line of the Catskill Aqueduct, about 15 miles north of the Hill View Reservoir. It has an available capacity of about 29,000,000,000 gallons, and will be able to supply the city with water for several months, in case the supply from the Ashokan Reservoir should be interrupted. The Kensico Reservoir is formed by a masonry dam, 1,850 feet long, having a maximum height of 310 feet above the lowest point of the foundation.

From the Hill View Reservoir, the water will be delivered to the five boroughs of the city by a circular tunnel, 18 miles long, driven through solid rock, 200-750 feet deep below the street surface (Fig. 17). The diameter of the tunnel is 15 feet at the Hill View Reservoir and is gradually reduced to 11 feet diameter at its terminus in Brooklyn. From two terminal shafts in Brooklyn, steel and iron pipe lines extend into the borough of Queens and Richmond. The supply to the latter borough is conveyed across the Narrows to Staten Island in a 36-inch flexible jointed, cast iron pipe, which was

buried in a trench in the harbor bottom. This line is extended on Staten Island by 48-inch mains to the Silver Lake Reservoir, which stores 435,000,000 gallons. The total length of the distributing system, including tunnels and pipe lines, is 34 miles.

From the short description given above, some idea can be formed of the magnitude of the great water works of New York.

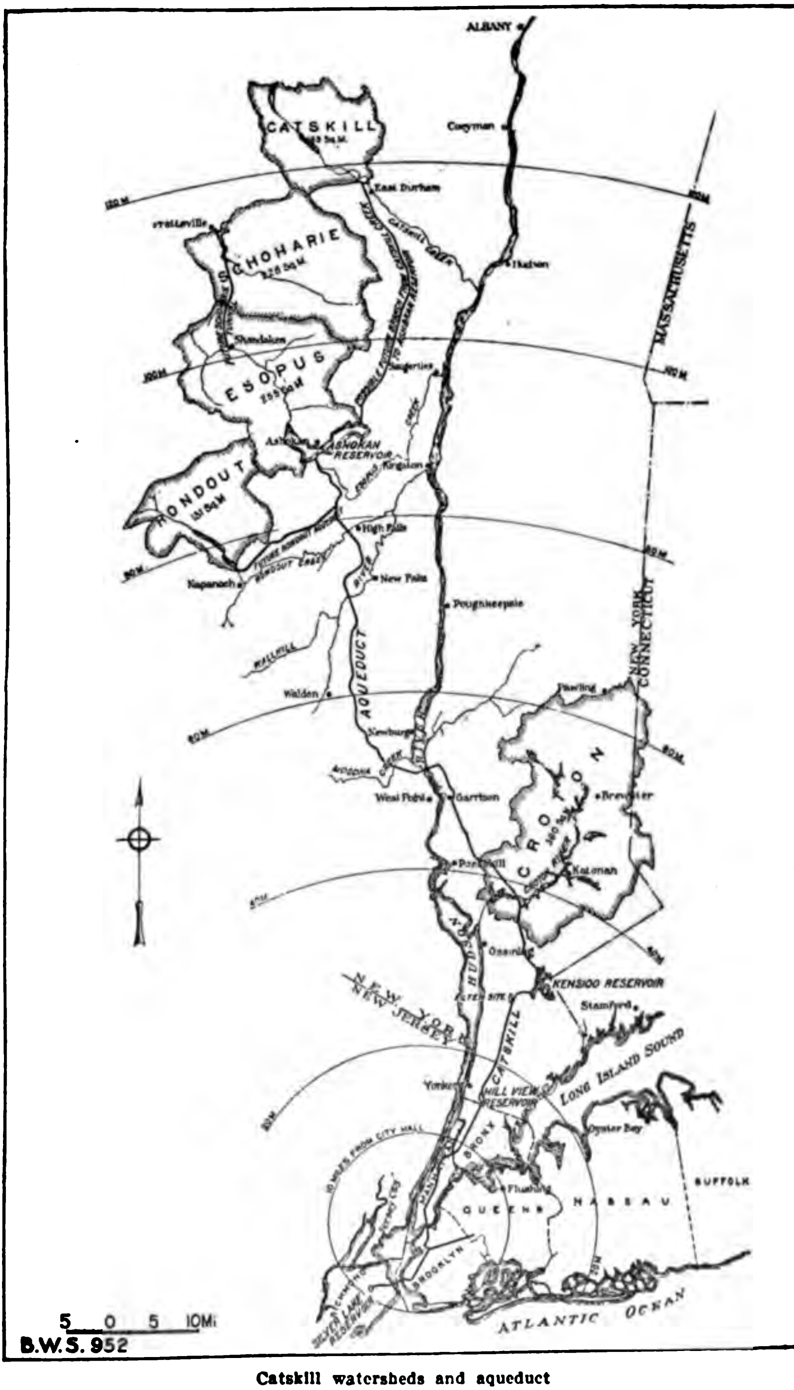
The growth of this city and the increase in the consumption of water is shown in the following table:

POPULATION OF THE CITY OF NEW YORK

Year.	Population.	Water Consumption
1790	33,131	....
1800	60,515	....
1810	96,373	....
1820	123,706	....
1830	202,589	....
1840	312,710	....
1850	515,547	40,000,000
1860	813,669	....
1870	942,292	77,000,000
1880	1,206,299	92,000,000
1890	1,515,301	145,000,000
1900	3,437,202	470,000,000
1910	4,766,883	500,000,000

*In 1898, Brooklyn, part of Queens County, and Staten Island were added to the City under the Charter of the Greater New York. This accounts for the large increase in population and water consumption at that time.

We have glanced now briefly at the greatest water works of ancient and of modern times. While the latter surpasses the former in magnitude and importance, the works constructed in ancient times with very primitive means and imperfect instruments excite the admiration of the modern engineer.



Catskill watersheds and aqueduct

Fig. 16.—Plan of the Catskill Aqueduct.

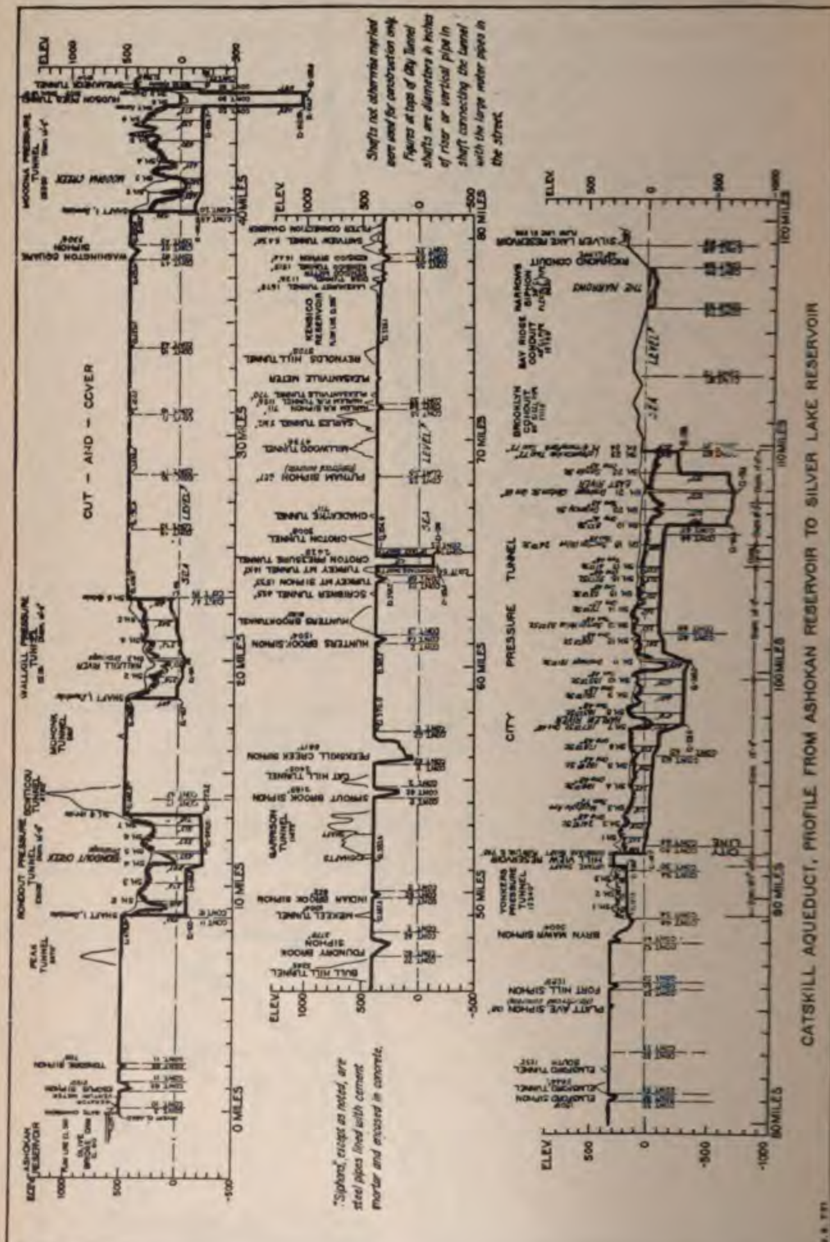


Fig. 17.—Profile of Catskill Aqueduct.

CITY TUNNEL—Showing locations of tunnel and shafts and pipe conduits

Fig. 18.—City Tunnel of Catskill Aqueduct.

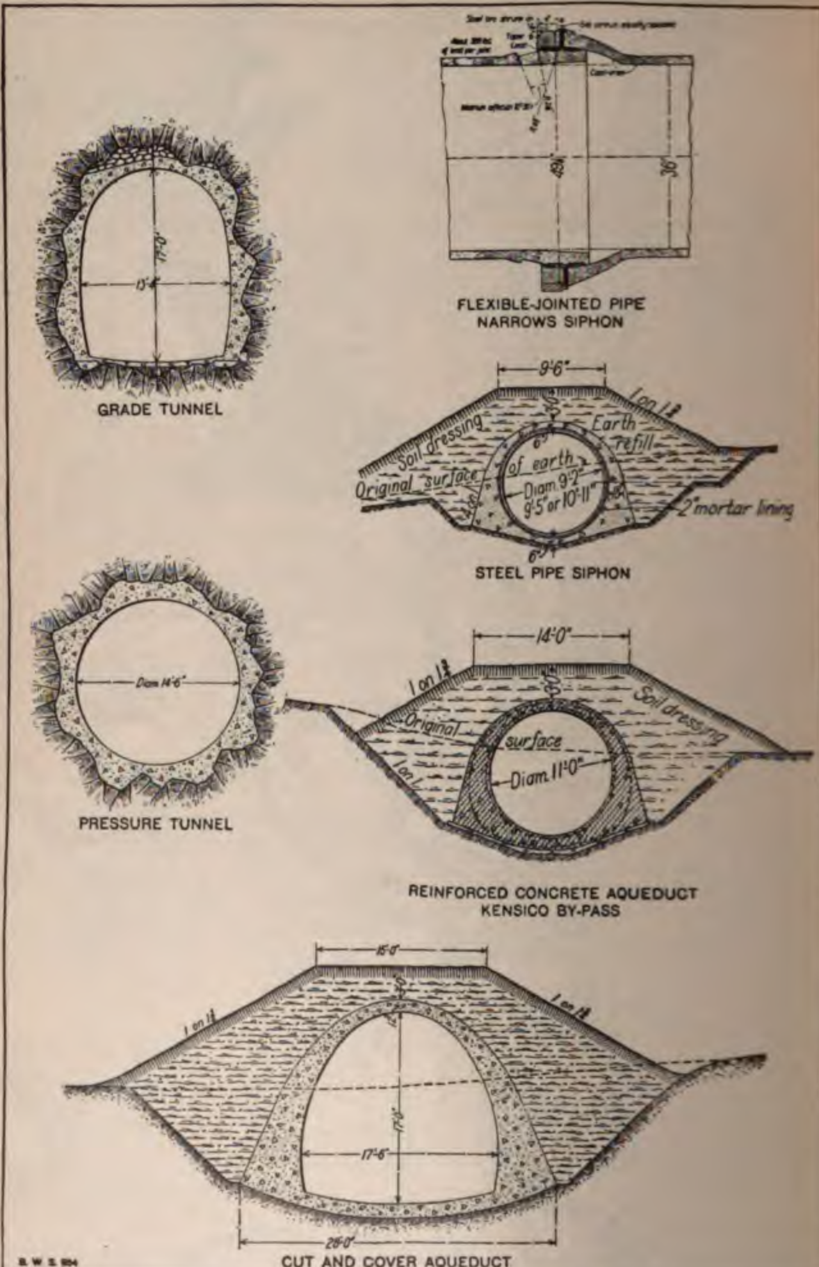


Fig. 19.—Cross Sections of Catskill Aqueduct.

FRANK A. HILL

Marked ability; wide experience in geology, mining and business; sound judgment, kindly frankness, absolute truthfulness; loyalty to his employers, his employes and his friends; devotion to his family; the consideration of the feelings of others and intense patriotism were the striking characteristics which made it possible for Frank A. Hill, throughout his life, to command the respect and esteem of all with whom he came in contact.

Frank A. Hill, whose death occurred July 13th, 1915, at Pottsville, Pa., was born at that place on January 30th, 1858. He was the son of the late Chas. M. and Maria G. (Ayer) Hill. He came to a family that had long been connected with anthracite mining, his father having, for many years been actively engaged as an operator and superintendent, operating the Oak Hill and other collieries in the Southern Anthracite Field.

Mr. Hill was educated in the private and public schools of Pottsville, graduating from the High School in 1875. Upon his graduation, he was appointed a Chainman on the Engineer Corps of the Philadelphia and Reading Coal & Iron Company under Gen. Henry Pleasants. With this company he remained until the organization of the Second Geological Survey of the anthracite fields in 1881, when he was appointed as an Assistant to Chas. A. Ashburner, geologist in charge. Mr. Hill's first work was in the Panther Creek district. Upon the organization of the other districts, he was assigned to the Northern Coal Field in charge of the work, with headquarters in Wilkes-Barre, and later at Scranton. In 1885, he was transferred to the headquarters of the Survey at Philadelphia and the conduct of the work in the entire Anthracite region was under his direction. In charge of this work he remained until 1890, when he was made Superintendent of the Dunbar Furnace Company, with offices at Dunbar, Fayette County, Pa. A short time after assuming charge of the furnaces and mines of this company there occurred the disastrous fire at the Hill Farm mine, resulting in the death of thirty-one (31) employes. His heroic conduct in attempting to rescue these men alive called forth the highest praise, not only from the Government Inspectors, but from the officials of the Labor Organizations and the relatives of the entombed men.

Resigning his position here in 1893, he was elected Vice-President and General Manager of the Southwest Virginia Improvement Company. With this company he remained until 1895, when he resigned to accept the office of General Manager of the Hull Coal and Coke Company, with headquarters in Roanoke, Virginia. With this Corporation he remained until 1908,

resigning to become Resident Director of the mining interests of Madeira, Hill and Company, establishing his headquarters in Pottsville. It was this position he held at the time of his death.

In October, 1893, Mr. Hill was united in marriage with Miss Alice Marie Muller, of Joliet, Illinois. To this union were born three children: Frank, Marie and Alexandria, who with his widow and sister survive him.

The funeral services, held at his late residence upon Friday afternoon, July 16th, were attended by prominent coal men from all parts of the Eastern United States. Interment was made in a plot recently selected by himself in the Charles Baber Cemetery, at Pottsville.

In the death of Mr. Hill the coal industry, as well as his friends, whom he numbered by the thousands, have met with a severe loss.

RICHARD W. GILPIN

Richard W. Gilpin, whose death occurred on June 21st, 1915, after a short illness, while at Cape May, N. J., where he had gone in the hope of regaining his health, was born near West Chester, Chester County, Pa., and received an academic education in the Episcopal Academy, Philadelphia, Pa.

His early fondness for scientific matters prompted his entering the employment of the Weston Electrical Co., of Newark, N. J., where he devoted all his time to the study of electrical engineering. After spending four years in the Weston electrical plant he entered the service of the United States Lighting Co. in New York, who were pioneers in the development of electrical house and street lighting in New York and other cities.

He established an office as Consulting Electrical Engineer in 1895 at 505 Chestnut Street, Philadelphia. In his capacity as Consulting Engineer he was a designer as well as adviser in the electrical heating and lighting equipment of many public buildings and private residences in Philadelphia and vicinity; notably, Academy of Fine Arts, Horticultural Hall, College of Physicians, Blind Asylum, Overbrook, Pa., a number of the Philadelphia Public Libraries and Princeton University.

At the time of his death he was a vestryman in the Church of the Ascension, a life member of the Franklin Institute, member of the Philobiblon Club, City Club, Pennsylvania Forestry Association and National Geographic Society. He was elected a member of the Engineers Club of Philadelphia in May 18, 1895.

Mr. Gilpin was at all times a most earnest advocate of a civic uplift in public affairs and did yeoman service as a member of the Seventh Ward Improvement Association.

TEILE HENRY MULLER

Teile Henry Muller—Born January 18th, 1841, at Grossensiel-Oldenburg, Germany. School in Oldenburg until 1857. Polytechnic School at Hannover 1858 to 1862. Ship engineer with North German Lloyd and English line to Africa. Located in New York in 1864 as draughtsman and machinist with the Root Steam Engine Co., in 1868 as Superintendent of the Convex Weaving Co., built their mill and designed and built the machinery. Went to the Eagle Pencil Co. to re-design machinery and revise process for manufacturing pencils, penholders, etc. In 1872 employed by Wm. Farmer as gas works engineer.

Designed the changes for the Sugar Refinery of Durand & Sons and from there, in 1877, went to S. S. Hepworth & Co., builders of sugar machinery. Designed the California Sugar Refinery in San Francisco for Mr. Claus Spreckles and the Belchers Refinery in St. Louis. Among the plantations fitted up complete was the "Cayalty" in Peru. In 1887 moved to Philadelphia and opened an office as consulting engineer. Designed and built the "Spreckles" Refinery, after a completion of which he designed for the Newhall Engineering Co., the National Sugar Refinery in Yonkers, for Mr. G. R. Bunker and supervised work in their office, the building of their sugar houses and machinery. Designed and partly built the Camden Sugar Refinery. Broke down from overwork and went to Europe in 1896 for the summer and returned to New York in 1897, where he was occupied mostly with the ice factories, until 1900, when he engaged with the Federal Sugar Refinery Co., as constructing engineer, and designed and built their works in Yonkers, died, September 20, 1915.

ABSTRACT OF MINUTES OF THE CLUB

REGULAR MEETING, JUNE 6, 1915

The meeting was called to order by President Ledoux, at 8.40 P. M., with forty-five members and visitors in attendance.

The minutes of the regular meeting of the Club held May 15th, 1915, were approved as printed in abstract.

Mr. W. Copeland Furber presented the paper of the evening, entitled "Modern School House Construction," which was discussed by Mrs. Edith Pierce, Mrs. Edw. Gryce and Dr. J. Madison Taylor. Meeting adjourned at 10.30 P. M.

REGULAR MEETING, SEPTEMBER 14, 1915

The meeting was called to order by President Ledoux at 8.30 P. M., with 75 members and visitors in attendance. The minutes of the meeting of June 6, 1915, were approved as printed in abstract.

The Secretary announced that at the Regular Meeting of the Board of Directors, the following had been elected: To Active Membership, Thomas H. Addie, Walter Blackson, J. Arthur Durst, H. Bayard Hodge, Richard S. Newbold, William E. Thomas, Henry C. Wright and Frederick James Ryan; to Junior Membership, Harry I. Goldstein. The Secretary also announced that T. Elmer Moon, member of the Illuminating Engineering Society, had been enrolled as an Active Member, in accordance with Article VI, Section 1, of the By-Laws.

The Secretary announced that the Board of Directors had submitted the names of the following men to constitute the Committee on Nominations for the ensuing year:

Robert H. Fernald, Chairman; John C. Trautwine, Jr., H. E. Ehlers, H. H. Quimby, R. G. Develin, Bruce Ford, W. C. Kerr.

Alternates: A. C. Vauclain, Charles F. Mebus and W. H. Fulweiler.

In accordance with Article V, Section 2, of the By-Laws, this list will be submitted to the Club at the October meeting for alteration or acceptance.

Mr. C. E. Drayer, of the Cleveland Engineering Society, presented the paper of the evening, entitled "Engineering Societies and Publicity," which was discussed by Messrs. John C. Trautwine, Jr., W. Copeland Furber, Morris L. Cooke, Frank L. Neal, P. A. Maignen, Prof. Robert H. Fernald and Dr. H. M. Chance.

ABSTRACT OF MINUTES
OF THE
BOARD OF DIRECTORS

REGULAR MEETING, SEPTEMBER 14, 1915

Present: Vice-President Snook, with Vice-Presidents Vogleson and Yarnall, Directors Hibbs, Wagner, Dauner, Moore, Bonine, Irish, Jones, Humphrey, Hess, Taylor the Secretary and the Treasurer in attendance. President Ledoux and Past President Swaab were excused. Directors Gibson, Worley, Andrews, Dunlap, Wilson, Tracy, Hornor and Davis were absent.

The minutes of the Regular Meeting of June 15th were read and approved. The minutes of the Special Meeting of July 19th were amended as follows:

"As no quorum was present, no official business was transacted, but the following opinion of the members present was expressed:

That we, members of the Board of Directors of the Engineers' Club, of Philadelphia, deem it advisable that the State Public Service Commission include an engineer of standing."

It was moved and carried that the Board ratify the action of the meeting of July 19th.

The President presented an analysis of the financial condition of the Club which, on motion, was referred to the Finance Committee with instructions that they examine it and submit a report at the Adjourned Meeting to be held September 21st.

The Treasurer reported a net loss of $548.99 as compared to a net loss of $202.45 for a corresponding period of 1914.

The Membership Committee's report was presented and the following elected:

To Active Membership: Thomas H. Addie, Walter Blackson, H. Bayard Hodge, Richard S. Newbold, William E. Thomas, Henry C. Wright, J. Arthur Durst.

To Junior Membership: Harry I. Goldstein.

Mr. Yarnall, Chairman of the Committee on Increase of Membership, stated that he had telegraphed the firm of Whitslar & Wells, Cleveland, Ohio, in regard to their terms to assist in conducting our campaign for increase of membership. Mr. Yarnall was authorized to confer with a

representative of this firm and submit a report to the Board at its Adjourned Meeting to be held September 21st.

A communication from the Engineers' Society of Northeastern Pennsylvania, requesting that our Club endorse the appointment of Mr. Charles Enzian as a member of the State Public Service Commission, was presented to the Board. The Secretary was instructed to notify the Society that the Club had urged the appointment of an engineer as a member of the Public Service Commission, but it did not at this time desire to endorse any candidate. The Secretary was instructed to communicate with Governor Brumbaugh to inform him that the Club would submit names of engineers for appointment as members of the Public Service Commission, if the Governor desired it.

A letter from Mr. F. H. Newell, Chairman of the Committee on Engineering Co-operation, was presented to the Board. Messrs. Yarnall and Hess presented a report of the meeting on Engineering Co-operation held in Buffalo June 23rd and 24th. The Secretary was instructed to forward Mr. Newell a copy of our pamphlet on "Engineering Fellowship" and inform him that we are in hearty sympathy with the proposed movement, and, furthermore, that by the affiliation of local sections of national engineering societies with the Club, the engineering co-operative movement is being developed in Philadelphia.

The deaths of Richard Gilpin (June 21st, 1915), and Frank Hill were announced.

In accordance with our By-Laws, Article V, Section 2, the names of seven members to constitute a Committee on Nominations for the coming year must be submitted by the Board of Directors to the Club at its September meeting. After some discussion as to the composition of the Committee on Nominations, the chair was authorized to appoint a committee of five men, who will submit to the Board at its adjourned meeting to be held September 21st a list of not less than ten names of men who are eligible for appointment on the Committee on Nominations. The chair appointed the following:

W. P. Taylor, D. Robert Yarnall, Henry Hess, Charles E. Bonine, Richard L. Humphrey.

The Chair was authorized to appoint a committee to thoroughly index the By-Laws.

A letter was read to the Board from the Engineers' Society of Pennsylvania, stating that they had cancelled their proposed excursion to Philadelphia.

The meeting adjourned at 9.45 P. M. to meet again on Tuesday, September 21st, at 7.00 P. M.

ADJOURNED MEETING, SEPTEMBER 21, 1915

Present: President Ledoux, Vice-Presidents Yarnall and Vogleson, Directors Irish, Gibson, Worley, Wagner, Bonine, Jones, Moore, Dunlap, Humphrey and Dauner, Past Presidents Hess and Taylor, the Secretary

and the Treasurer in attendance. Vice-President Snook was excused. Past President Swaab and Directors Hibbs, Andrews, Wilson, Sanville, Hornor and Davis were absent.

The minutes of the regular meeting of September 14th were read and approved.

The Committee on Nominations presented its report, and the Board directed that the following names be submitted to the club in accordance with the provisions of the By-Laws, Article V, Section 2, to constitute a Committee on Nominations for the current year:

Robert H. Fernald, Chairman; John C. Trautwine, Jr., H. E. Ehlers, H. H. Quimby, R. G. Develin, Bruce Ford, William C. Kerr.

Alternates: A. C. Vauclain, Charles F. Mebus, W. H. Fulweiler.

The Secretary announced that T. Elmer Moon, member in good standing of the I. E. S., had been enrolled as an Active Member of the Club, in accordance with Article VI, Section 1, of the By-Laws.

Upon recommendation of the Membership Committee, Frederick James Ryan was elected to Active Membership.

Percy H. Wilson was reinstated to Active Membership as of March 17th, 1913.

Appropriation of $21.00 to list the affiliated societies in the telephone directories was authorized.

Communications were received from the A. I. E. E. and the I. E. S. regarding the payment of dues for members of these affiliated societies. A motion was made and carried that the list of members submitted by the Secretary of these societies, as of April 1st, should constitute the official list on which they would pay membership dues during the Club fiscal year.

Communication from the Engineers' Society of Western Pennsylvania relative to submission of names of engineers who might be eligible for appointment as members of the Public Service Commission was ordered to be tabled until the next regular meeting of the Board.

Messrs. Hess and Yarnall spoke regarding the work of the Increase of Membership Committee, and the following motion was passed:

That the Increase of Membership Committee be authorized to enter into an agreement with the firm of Whitslar and Wells, of Cleveland, Ohio. terms not to exceed five per cent. of the dues received from new members in their first year as stipulated in our By-Laws, and that the committee be authorized to expend an amount not exceeding $1000 for the expenses of the Increase of Membership Campaign, and that the committee be given full power to act.

The meeting adjourned at 8.30 to convene at 9.30. The Board reconvened at 9.30 to discuss the report of the Finance Committee. The following recommendation of the Finance Committee was approved by the Board and ordered to be placed in its regular order of business:

The Finance Committee has come to the definite conclusion that much of its difficulty, as well as the difficulties of the various committees and of the Board with relation to the finances and the proper appropriation of the Club's income is due to the improper timing of the making up of budgets and their submission. At the meeting of the Finance Committee of March 16th, 1915, this was touched upon, and the recommendation then made to the Board the Finance Committee now presents more in detail.

For instance, the Finance Committee, at its meeting of March 16th, was supposed to make recommendations to the Board for its budget, and did not then have any knowledge or recommendations from the various committees as to their needs and a report had to be submitted to the Board March 16th. Manifestly, it was totally impossible for the Finance Committee to present to the Board within two days a properly digested report.

It is therefore recommended that each committee have its report prepared for the Finance Committee on March 1st at the latest, and that the Finance Committee submit its report in turn to the Board at its April meeting. This will result in each committee's working out its report and a budget, after it has had almost a year's experience, and in the Finance Committee's working out its report and budget after having had, similarly, almost a year's experience. In that way the Finance Committee's report goes to the Board with its almost full year of experience, and it can act on the similarly full year's experience of the Committees and Finance Committee. Under the present plan, each committee, the Finance Committee and the Board had to take action without any previous experience to guide it, so far as the committees and Board as a whole are concerned. Under this plan, the Finance Committee has six weeks in which to consider the various committee reports and to confer, possibly, several times with those committees. The Board has then two meetings in which it can consider the Finance Committee's report and translate it into action. The intervening month thus gives the Board ample opportunity for further detail conference with the Finance Committee. The whole plan would be of distinct advantage to an incoming Board, since it would not at the outset be confronted with the most difficult work that it has to deal with, i. e., the Club's budget, but would, in turn, have to deal with it as before stated, after having had practically a year's experience.

The Board approved the recommendation of the Finance Committee that the Club negotiate a loan for $5000 and authorized the issuing of notes to this amount for six months at six per cent., $1000 of this amount to be set aside to defray the expenses of the Increase of Membership Campaign. It was considered desirable that this loan be raised within the Board.

The Board ordered that the note issue be cancelled by the Club at the earliest practicable date, the order of payment being first, the $250 notes; second, the $500 notes and, finally, the $1000 notes.

The Board, on recommendation by the Finance Committee, authorized the Treasurer to transfer all of the accounts of the Club, excepting the second mortgage bond interest account, from the Colonial Trust Company to either the Franklin National Bank or the Third National Bank, preference to be given the bank which offered the better terms.

REGULAR MEETING, OCTOBER 12, 1915

Present: Vice-President Vogelson and Yarnall, Directors Gibson, Wagner, Andrews, Irish, Crampton, Humphrey, Past Presidents Swaab and Taylor and the Secretary in attendance. President Ledoux and Director Moore were excused. Vice-President Snook, Directors Hibbs, Worley, Dauner, Dunlap, Bonine, Jones, Wilson, Tracy, Davis, Past President Hess and the Treasurer were absent.

As no quorum was present, the reading of the minutes of the September 21st meeting was dispensed with. The members present decided to act upon those matters which required immediate action, and leave the ratification of the actions to a subsequent meeting of the Board.

The Treasurer's report was presented and approved.

The Secretary presented a communication from James Logan and was instructed to transmit to him the By-Laws covering the question of dues raised in his letter.

The Secretary announced that the members elected by the Board of Directors to constitute the Committee on Nominations had accepted their appointment.

Exchange of privileges with the Engineers' Club, of Kansas City, was authorized by the Board.

The Secretary was instructed to communicate with the Engineers' Society of Western Pennsylvania, asking them to notify the Engineers' Club as to the nature of the Governor's reply to their letter of September 18th.

The Secretary announced that Dr. G. S. Crampton had been appointed vice H. A. Hornor (I. E. S.) and Joseph Tracy vice H. F. Sanville (A. I. E. E.), members of the Board of Directors.

The Membership Committee's report was presented, and the following elected to Active Membership: Robert Mann Barr, Carl G. A. Schmidt, Jr.

INDEX VOLUME XXXII*

* The July issue of 1915 was numbered Vol. XXXI, No. 3, and should have been numbered Vol. XXXII, No. 3.

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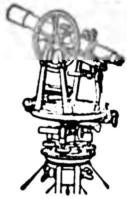

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